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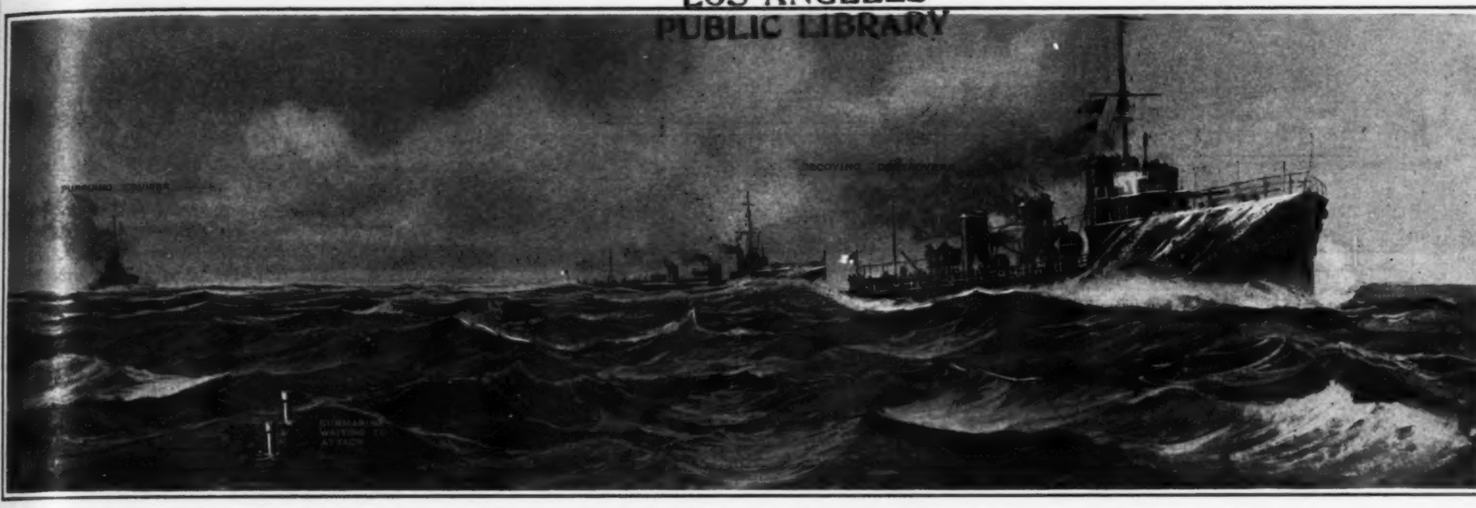
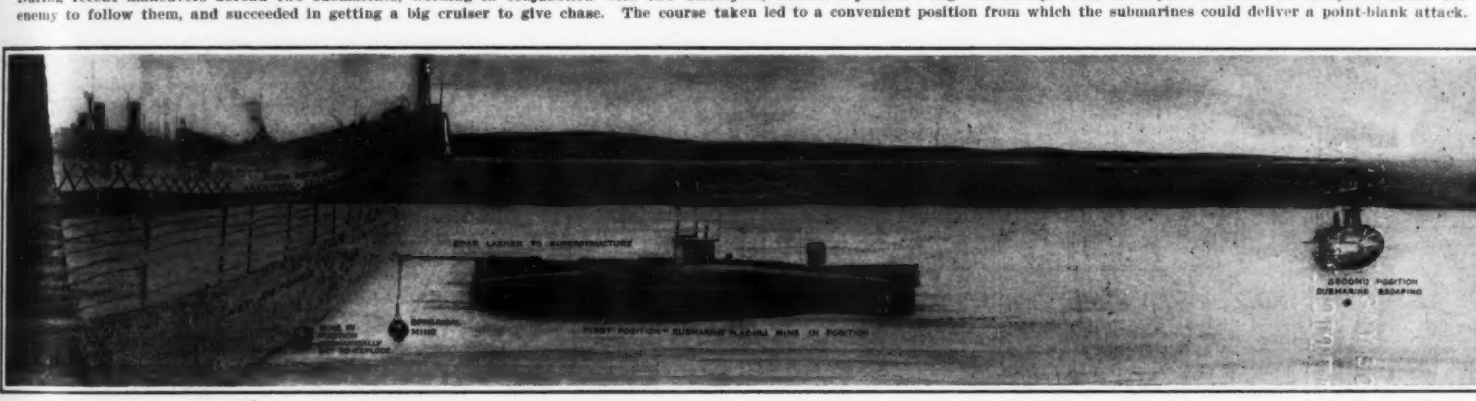


The decoys luring a battleship toward waiting submarines.

During recent maneuvers abroad two submarines, working in conjunction with two destroyers, formed a plan to "bag" an enemy. The destroyers went out as decoys to entice the enemy to follow them, and succeeded in getting a big cruiser to give chase. The course taken led to a convenient position from which the submarines could deliver a point-blank attack.



A submarine attack on a protected harbor.

Showing how a submarine, by means of a long spar lashed to its superstructure, was able to place a mine which completely destroyed a net and boom that was supposed to thoroughly protect a harbor from submarine attacks.

From "The Sphere." Drawn by G. H. Davis.

Submarines confining dreadnoughts to harbor.

SUBMARINE AND DREADNOUGHT.—[See page 118.]

Protection of Battleships Against Submarine Attack*

By Sir John H. Biles, LL.D., D.Sc.

In this Institution we have a meeting ground for the statesman, the naval officer, and the ship constructor. The first directs the second, and the third supplies the second with his weapon. We ship constructors are sometimes taken into the confidence of the naval officer, and we try to understand as much as we can of the nature of the onerous duties which he has to perform. We are told that the navy exists to keep the command of the sea, and that command of the sea is necessary for its freedom. To keep the command it is desirable—some say, necessary—to discover and destroy the enemy's forces. Battleships, cruisers, destroyers, submarines, must all be caught and destroyed or captured, and, equally, all must be capable of resisting destruction or capture. In the two dimensions represented by the surface of the sea, with equal powers of vision, getting within destroying distance is a question of speed, and destruction is a matter of superiority of attack over the defense. The dominating weapon of attack has been the gun, and the defense against it has been practically all above water, because there its attack has been made. The torpedo-boat and, later, the destroyer, have delivered their main attack below water, but the attacked ship is held to be quite capable of delivering a counter attack by guns above water, which is an adequate reply to the destroyer. The attack of the submarine is wholly below water, and so far the attacked ship has developed no effective reply of its own. The defense against the gun is armor and other guns. The defense against the destroyer's torpedo is the gun, which is quite ineffective against the submarine. The question of interest at the moment is: What defense can the surface ship have against the submarine's torpedo?

There can be only two forms of defense. First, the destruction of the submarine by other vessels, submarine or others. Second, the protection of the bottom of the surface ships from the effects of under-water attack. The first, the destruction of the submarine, is obviously not the work of a battleship or large cruiser, but must be left to some vessel of the same order of size as the submarine. This destruction must be sought on the surface when the submarine is not submerged, for it seems improbable that a submarine will be able to chase another effectively under the water. In any case, the submarine will be dangerous to the large surface ship until it is destroyed, and, as the means of destruction are not yet certainly to hand, the question of effectively protecting the battleship against under-water attack seems to be deserving of consideration, unless someone is ready with a real reply to the submarine.

One naturally is first met with the question: What about the weight of such protection? The same question can, of course, be asked in the same attitude of mind about any weights used in a ship for the purpose of attack or defense. What about the weight of armor to keep out shot? The thickness and extent of protection ought to be proportioned to the liability to be hit and the damage done when hit. This principle is given effect to when distributing armor protection over a ship to resist gun fire. What is the relative damage done by a 15-inch shell and a 21-inch torpedo, and what is the relative liability to be hit by these projectiles? A distinguished gunner told you in this Institution in April that a modern battleship will be destroyed by gun fire in five minutes after fighting range has been reached. The submarine officer will tell you he can get a torpedo into any ship that he can see and can get within the range of his torpedo. The battleship can hit back at his enemy battleship, but can do nothing by himself against the submarine. What is the liability to be hit in the two cases? Can the submarine find the battleship as surely as the enemy battleship can? In other words, what is the relative liability to be hit by the two methods of attack? This is for the naval officer to tell us, if he can. If the relative liability to be hit is sufficiently great to warrant full consideration of the relative damage, we shall also want to know this. Assuming, as one reasonably may, that very serious damage will be done by the explosion of a torpedo, the next question is: What can be done to prevent or seriously to reduce this damage? Subdivision naturally suggests itself as one means of minimizing the effect of this damage, but when all that is possible in this direction has been done, there seems to be no great certainty that a battleship will be still a formidable fighting machine after having received the successful contact explosion of a 21-inch torpedo. Can we do anything in addition to subdivision to preserve the ship for effective fighting purposes?

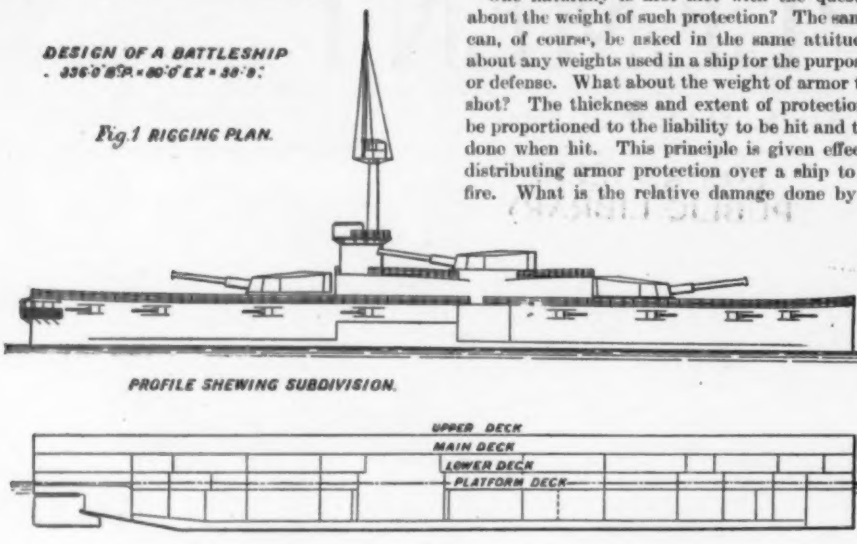
Armor on the bottom of warships has been proposed by responsible persons. Sir E. J. Reed and General Sir John Crease, R.M.A., during their lives made definite proposals of this character, but they have never been adopted on the outsides of ships, partly for the reason that, previous to the submarine, the torpedo-carrying vessel has been effectively answered by the gun, and partly because the resisting qualities of armor, when submitted to attack by torpedoes, have not been sufficiently well known. The effective advent of the submarine seems to justify a serious consideration of the question of applying armor to the bottoms of ships.

The question of the weight of such armor must be serious, and obviously the addition of such weight cannot be made without some changes and sacrifices. To some it may seem that the readiest way to approach this problem is to clothe the bottom of a 25,000-ton battleship of the latest pattern with armor, and to increase her fullness sufficiently to allow her to carry this armor, letting everything else remain unaltered. The only considerable effect will be to reduce the speed by two knots.

This is a direct and simple issue—is the gain in pro-

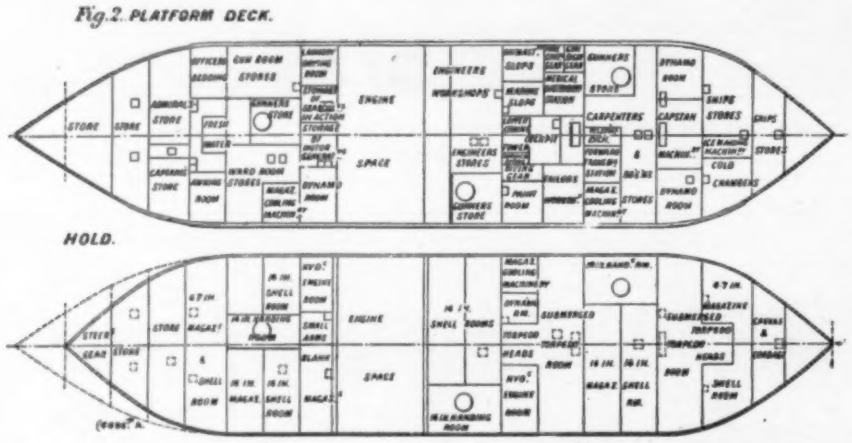
DESIGN OF A BATTLESHIP
. 336'0" B.P. × 80'0" EX × 38'9".

Fig. 1 RIGGING PLAN.



PROFILE SHEWING SUBDIVISION.

Fig. 2. PLATFORM DECK.



HOLD.

Fig. 3.

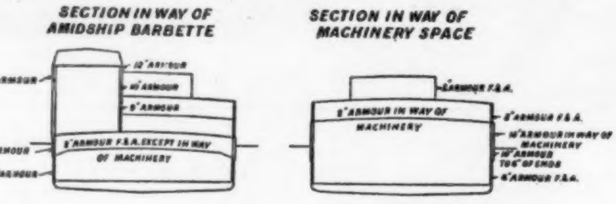
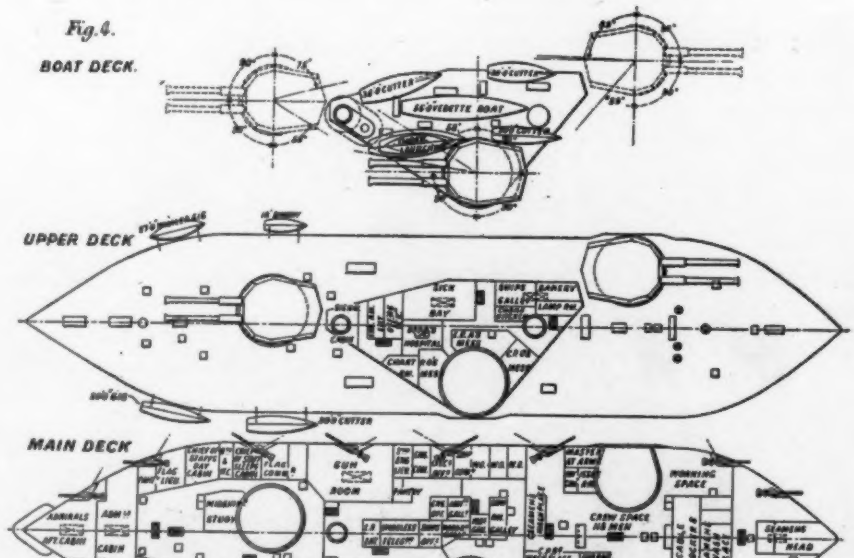


Fig. 4.



*Paper read before the Institution of Naval Architects at Newcastle, on July 7th, 1914.

tection worth the loss of speed? This is for the naval officer to decide. The constructor will naturally find difficulties in the way of attaching such armor protection, but he has surmounted difficulties before, and if the naval officer thinks the result worth attaining, the difficulties will doubtless be overcome.

It is not always that the readiest way of approaching a problem gives the best result. One of the characteristics of our latest battleships is that their forms have a low resistance to forward motion. If a form is produced which is better adapted to fitting and carrying armor, though it may involve greater resistance or less speed, it may on the whole be better to adopt such a form. It may be interesting to give an instance or two of the application of this principle. Admiral Sir Reginald Custance has taken us into his confidence about some of his views on the principles which he thinks should underlie naval design. His appreciation of lower speeds and smaller displacements led me to work out what appeared to me to be a limiting case of his views, but combined with these characteristics was associated in this case an armored protection from torpedo attack. The principal elements of the resulting design were as follows:

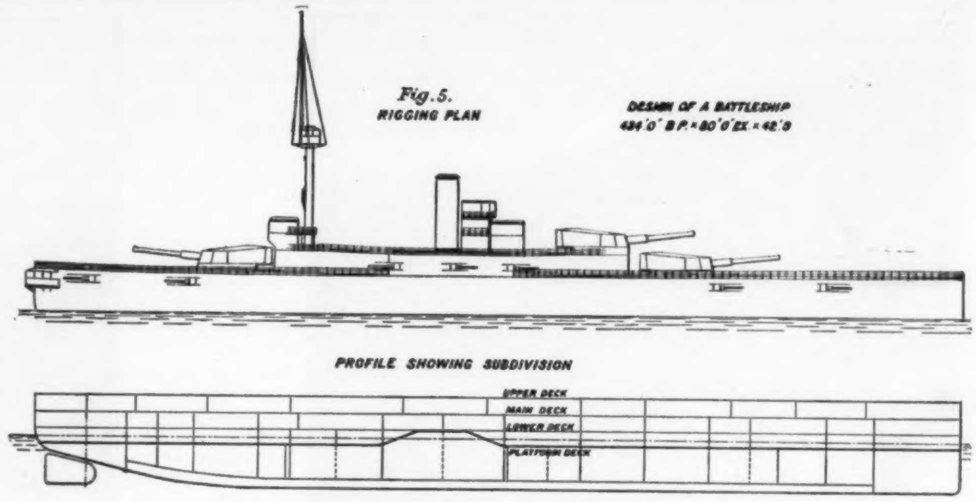
Length over all	358 ft.
Length between perpendiculars	336 ft.
Breadth, extreme	80 ft.
Draught of water	20 ft.
Displacement in tons	13,000
Speed	10 knots
Armament	six 14 in.; sixteen 5 in.
Thickness of armor:	
On side at W. L.	10 in.
Above W. L.	3 in.
Below W. L.	4 in.
On casemate	2 in.
On barbettes	12 in.
Thickness of protective deck-plating	2 in.

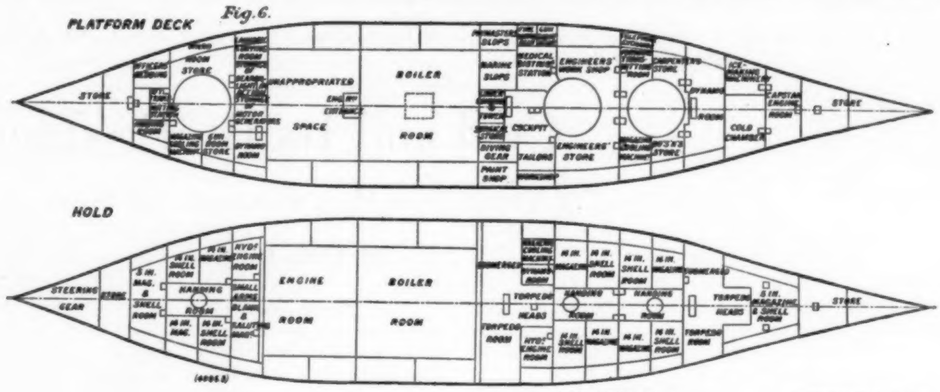
This vessel may be considered as one which could not be expected to find the enemy unless he happened to be bottled up somewhere, but could be less careful than an ordinary battleship about coming out of port on account of the fear of submarines. The size and cost of this vessel should be small enough to satisfy the desires of Admiral Sir Reginald Custance, but it is doubtful whether she would be altogether satisfactory to him.

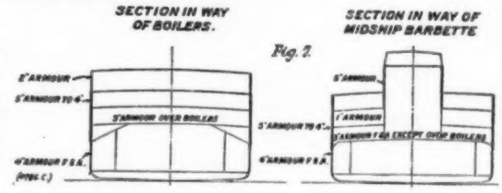
Anticipating some want of faith in this unusual vessel, a second design was produced, having some of the characteristics of the first, but being produced with less disregard of convention. The principal elements are as follows:

Length over all	460 ft.
Length between perpendiculars	434 ft.
Breadth, extreme	80 ft.
Draught of water	24 ft.
Displacement in tons	16,000
Speed	18 knots
Armament	six 14-in.; sixteen 5-in.
Thickness of armor:	
On side at W. L.	5 in.
Above W. L.	5 in.
Below W. L.	4 in.
On casemate	2 in.
On barbettes	5 in.
Thickness of protective deck-plating	2 in.

This vessel is of about the displacement of the "Lord Nelson," which is, when purpose serves, called a dreadnought. The armament is about the same as the first design, but the armor has been reduced so that it will only keep out 6-inch projectiles. Sir Reginald's view is that none of our ships have armor that will do more, and, that being so, this ship may be considered as sufficiently well armored above the water-line. All the sections below the water-line are straight, with a circular arc at the end. This form has been adopted to simplify the armor construction of the bottom. It is fully recognized that such a design outrages the convictions of the economists, to whose ranks I want to belong, because ships of such size do not produce the greatest number of guns for a given expenditure. But if we are to be subjected to the ready loss of ships by submarines, we may have to be prepared to sacrifice some gun power for our expenditure, and get our recompense in the greater number of ships and guns remaining afloat after the submarine has done its work. It is very rash on the part of a mere naval architect to attempt to reach any conclusion on this difficult question. The facts and figures are placed before this Institution, so that those who are competent to form an opinion may have the opportunity of doing so.







With a view of enabling those who do not believe in reducing the upper armor of a ship, nor in such a low speed as 18 knots, another design has been considered in which the bottom is armored, and is of a form similar to the second design, but in which the speed, armor, and armament are of the same order as the dreadnoughts. Such a vessel could take her place in the first or second battle squadron, and would have armored protection against torpedoes. The principal elements are as follows:

Length over all	600 ft.
Length between perpendiculars	570 ft.
Breadth, extreme	91 ft.
Draught of water	28 ft. 6 in.
Displacement in tons	28,500
Speed	21 knots
Armament	ten 14-in.; sixteen 6-in.
Thickness of armor:	
On side at W. L.	10 in.
Above W. L.	7 in. and 5 in.
Below W. L.	4 in.
On casemate	2 in.
On barbettes	12 in.
Thickness of protective deck-plating	3 in.

Briefly, the points for discussion are as follows:

1. Is 4-inch armor sufficient protection against torpedoes to justify its adoption in battleships of the class of the later dreadnoughts?

2. Is the submarine menace of sufficient importance to justify the adoption of 4-inch armor protection on the bottom?

3. Is the submarine menace of sufficient importance to justify the building of smaller, slower battleships of, say, 16,000 tons displacement, of 18 knots, having six heavy guns each instead of eight or ten as in the larger ships?

4. Is the method of applying armor to the bottom of sufficient value in itself to justify the adoption of a form of ship which offers greater resistance than the ordinary form?

These are some of the points which suggest themselves for discussion. The form and arrangement of existing ships, though not revealed to us by the Admiralty, may be considered, for this purpose, as sufficiently well known to many to make it unnecessary for a third design to have been embodied in this paper. If it should seem to be desirable, further, to consider this question of protecting battleships from submarine attack, it will be necessary to determine by experiment the effect of the explosion of a torpedo upon armor attached to a ship. If the submarine menace is judged to be really serious, the necessity for carrying out such experiments seems to be undoubted.

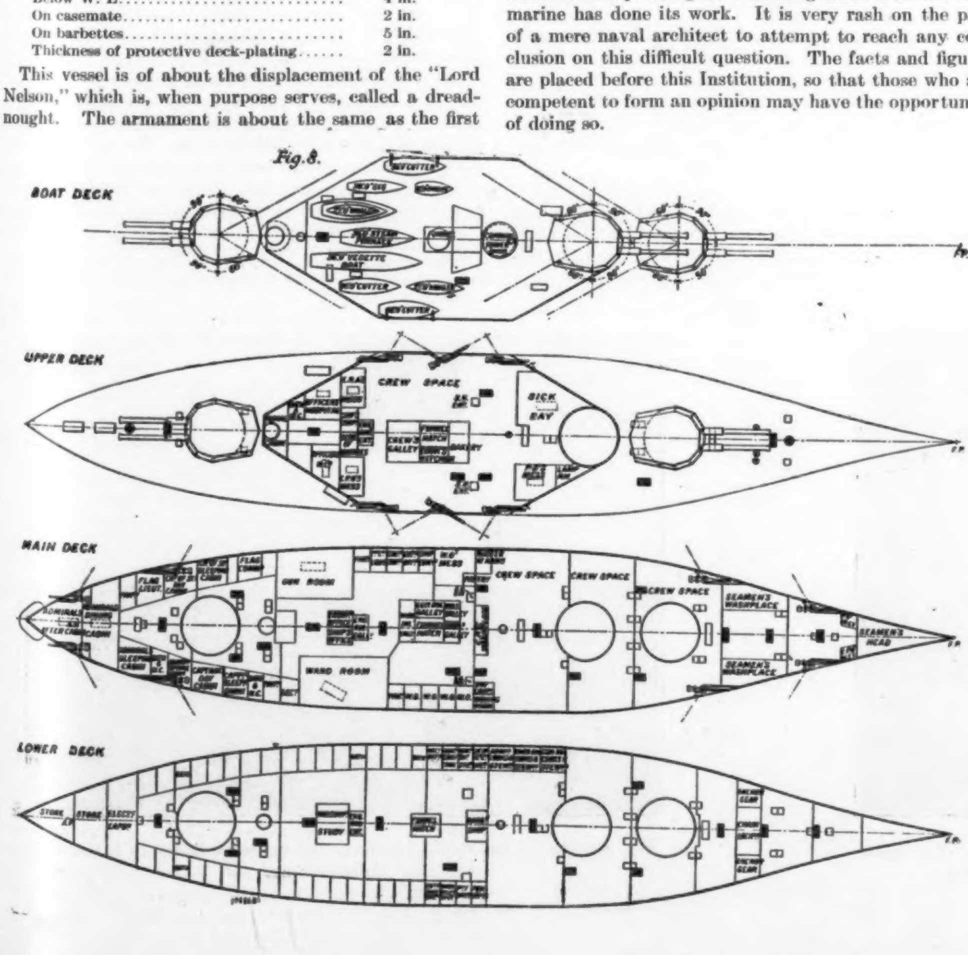


Fig. 1.—Railroad tunnel piercing nearly vertical layer of Lee conglomerate near Big Stone Gap, Va.

Fig. 2.—Typical scene in Letcher County, Ky., showing log cabin and path leading to coal opening in the mountain side.

Coal and Its By-Products—I*

How, and of What Coal Was Formed, and Some Account of Its Utilization

By Louis Cleveland Jones, Ph.D.

There have been listed and described perhaps several hundred thousand organic compounds, practically all of which can be obtained directly or indirectly from the decomposition of coal by heat.

Carbon, oxygen, hydrogen, nitrogen, sulphur, phosphorus, and the halogens are normal constituents of ordinary coal, so that all compounds containing any or all of these substances, in any proportion, are possible direct by-products of coal. Coal also at times contains unusual constituents such as the rare elements in the ash, even gold and radium. We have known a coal ash to contain so much gold that the possibility was considered of treating its ash after burning, as a gold ore. There are seams of coal in southern Indiana and eastern Kentucky which contain iron ore. The ash of some coals in western Pennsylvania and eastern Kentucky makes an excellent high-grade, refractory fire-clay. One of the principal coal seams in Illinois consists of an upper bench of limestone.

But the true by-products of coal are the organic products, and they are so numerous that it would weary you to mention even all their group names. Acid bases, alkaloids, alcohols, gums, varnishes, solvents, sugars, saccharine, and stuffs as bitter as saccharine is sweet, disinfectants, dye stuffs of brilliant hues, stimulating or sleep-producing drugs, healing medicines and violent poisons, vile odors and pleasing perfumes, are all by-products from the carbonization of coal.

But I must not weary you with the recital of these products and their nature, for I wish to consider the nature of coal itself.

In order more clearly to understand what coal is, we must look into its origin.

* Presented at the meeting of the Section of Physics and Chemistry of the Franklin Institute, and published in its *Journal*.

Early Atmosphere of the Earth.

A generation ago it was not good science to talk much about transmutation. However, after the recent accomplishments of Madam Curie, Sir William Crooks, Prof. Rutherford, and others, transmutation has been brought again into the realm of science.

After the primordial substance had been transmuted into some eighty present well-known elements, and these were still in the condition of vapor uncondensed, there was present, fortunately, sufficient oxygen to combine with all the other elements which cared to associate with it, and just a little more. These vapors cooled and condensed to a molten mass in the form of a sphere—our earth. Forty-five per cent of the earth's crust, say one quarter of the whole weight of this sphere—the earth—is represented by the oxygen which has combined with other elements to form rocks and water. One quarter of the weight of the earth represents 32 billion trillion tons of oxygen, and there was left over uncombined in our atmosphere 670 trillion tons, or only two millionths of one per cent of the total. So you see that it is by a rather close margin that we now have enough oxygen in our air to enable human beings to live.

The earth, now cooled to the condition of a fairly homogeneous fused mass of rocks, may be compared with a tank of fluid melted glass, composed of impure mixed silicates with an excess of silica, about 75 per cent of the total weight of the earth's crust, while the mixture in an ordinary glass furnace contains also about the same percentage (70 to 75 per cent) of silica.

Above this fused mass was an atmosphere containing the present amount of air (nitrogen and oxygen), and also as steam all the water now condensed in the ocean, and all the carbon dioxide now fixed in the form of limestone (calcium carbonate). There was also present, of course, in that atmosphere, relatively small amounts of sulphur and halogens, since deposited as salts.

A rough estimate indicates that the total amount of water now in the world, if evenly distributed, would cover all the earth's surface 10,000 feet deep (say 3,000 meters).[1] Likewise the limestone deposits of the earth's surface are, on the average, 6,000 feet (say 1,800 meters) deep.

On this basis, then, and since one atmosphere equals 10 tons per square meter of surface, we can readily calculate that, with all the water as vapor, and all the carbon dioxide as gas in the atmosphere, the pressure upon the earth's surface would be enormous, i. e.:

=300 atmospheres water vapor.
200 atmospheres carbon dioxide.
1 atmosphere nitrogen and oxygen.

Thus the earth's atmosphere was composed, by volume, of

	Per Cent.
Steam	79.2
Carbon dioxide gas	20.4
Air (oxygen and nitrogen)	.35

all under a pressure of say 500 atmospheres, or 7,350 pounds per square inch. Under these conditions cooling was rapid, due to the continuous condensation of water vapor high in the atmosphere, and its re-evaporation lower down.

When the earth's crust became sufficiently cool the solid granite masses, thrust up by contraction, were violently attacked by this superheated steam and carbon dioxide under tremendous pressure. Decomposition of the granite was rapid, with formation of shales (aluminium silicates) and bases (alkalies and alkaline earths) from feldspars, and sandstones (silica) from quartz. Cooling continued below the boiling-point of water so

[1] Calculated from average depth of oceans as determined by measured speed of volcanic tidal waves crossing the Pacific.

Fig. 3.—The thickest opening in Elkhorn seam, Kentucky. The horse is standing on a level with the bottom of the coal seam.

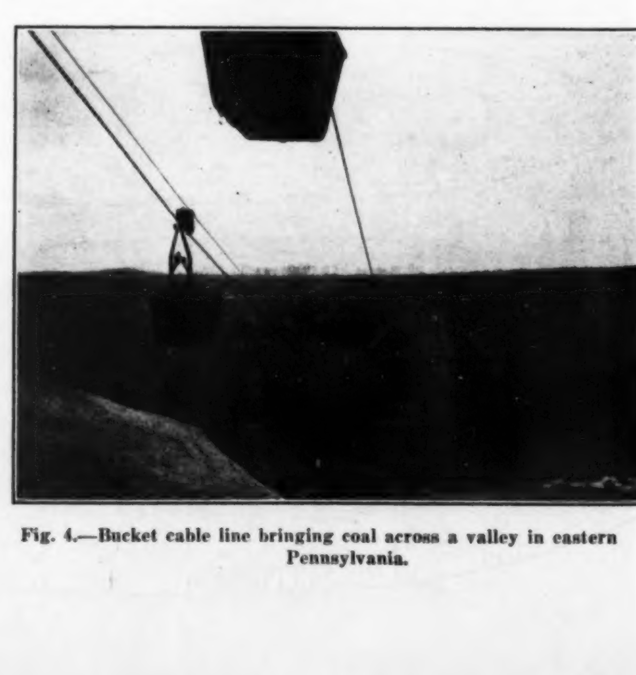


Fig. 4.—Bucket cable line bringing coal across a valley in eastern Pennsylvania.

that most of the water condensed, leaving a moist atmosphere containing principally CO_2, i. e., over 98 per cent of CO_2, and less than 2 per cent of nitrogen and oxygen together.

In these warm waters shales and sandstones were sedimented, and at the same time lime from the decomposed granites was carbonated or bicarbonated and deposited to form the enormous limestone beds of the geologic ages preceding the coal-forming era.

Since our limestone deposits are generally sedimentary it is evident that much water had condensed before the great bulk of the carbon dioxide was taken from the air by the decomposing granites. At any rate, in this manner, at the same time water was condensed, or subsequently, the formation of limestone (possibly, as Dana says, by means of animal or vegetable organisms), with absorption of carbon dioxide, continued until, with decreased temperature and decreased amounts of carbon dioxide in the air, plant and animal life became possible. Experiments indicate that plants of our time will not thrive in an atmosphere containing more than 10 per cent of carbon dioxide, but that they do benefit considerably by percentages higher than normally present in our air. Certainly in the carboniferous era plant life flourished as never before or since, due to a warm, moist climate, and probably also to high atmospheric pressure, and particularly in the presence of a moderately high percentage of carbon dioxide. Possibly also the highly carbonated earth waters, as recent experiments suggest, stimulated a luxuriant growth of vegetation.

Fig. 5.—Typical drift mine in Tug River district, West Virginia.

AMOUNT OF CARBON DIOXIDE IN THE ATMOSPHERE IN COAL ERA.

The ratio of the thickness of limestone beds, deposited before the beginning of the coal-forming era, to the limestone formed from granite decomposed since, would permit us to calculate what amount of the 98 per cent of carbon dioxide originally present remained in the atmosphere when our coal beds were formed. Such estimates are extremely indefinite, but it is quite probable that the atmosphere of the coal-forming era contained from 2 to 5 per cent of carbon dioxide, while at present, as we know, we have but 0.03 of one per cent. Furthermore, this carbon dioxide and high moisture content of the air doubtless brought about a more uniform distribution of heat, so that at any rate tropic vegetation flourished from the equator to the poles.

In addition to the absorption of carbon dioxide during and since carboniferous times to form limestones, the great coal deposits of the world have taken their carbon equivalent from the carbon dioxide of the atmosphere.

CO_2 REQUIRED TO FORM COAL.

A committee of the Twelfth International Geological Congress, held in Canada last fall, determined the total minable coal deposits of the world to be at most 7,400 billion tons. Double this, or 14,800 billion tons, may be taken to safely represent all other coal in thin seams beneath the ocean and in other ways not minable.

Now, if we compare our total coal deposits, 15,000 billion tons (calculated into its equivalent of carbon) with the 0.03 per cent of carbon dioxide still in our atmosphere (equivalent to 700 billion tons of carbon), we get the striking information that the coal deposits of the world required and took from the air 11,000 billion tons of carbon for their production, and there are left in the air to-day but 700 billion tons of carbon, or but 6 per cent of the total originally required to produce the coal we have. In other words, no more coal could have been deposited because the raw material was practically used up. This world cannot, therefore, have another carboniferous era until we burn up our present deposits, and when we do get them burned up there will reasonably be, say 0.6 per cent more CO_2 in the atmosphere, and the same amount less of oxygen than at present.[2]

FLUCTUATIONS OF CARBON DIOXIDE IN THE ATMOSPHERE.

How much carbon dioxide has been absorbed by granites decomposed since the beginning of the carboniferous age is not readily determined, but the larger amount present at that time, besides directly giving richer food to plant life, has been considered sufficient to so modify climate as to account for the tropical conditions prevalent at that time.

Arrhenius and Chamberlain have attempted to explain the known fluctuations of climate as indicated by glaciation by corresponding fluctuations in the carbon dioxide of the atmosphere. But a sufficient cause for such changes in the amount of carbon dioxide is hard to find. We may estimate the earth's water to contain perhaps seven parts carbon dioxide per one hundred thousand, in the form of bicarbonates, more than sufficient if transferred to the atmosphere to supply carbon for another coal-forming epoch, but boiling would be required to drive it into the atmosphere.

The decomposition of a small portion of the limestone, by heat or otherwise, would, of course, return the requisite amount of carbon dioxide to the air to give again to earth universal tropical conditions. Without heat, however, an acid would be required to evolve carbon dioxide, but no such acid suggests itself other than a rather improbable one, i. e., nitric acid, formed by oxidation of nitrogen by electrical discharges which the earth in its history may have developed or encountered.

AMOUNT OF CARBON DIOXIDE NOW IN ATMOSPHERE CONSTANT.

It would not be unreasonable to estimate that the ordinary growth of vegetation and forestry may consume 400 grammes of carbon dioxide per square meter of surface per year, or 100 grammes per square meter over the entire surface of the earth, or about 2 per cent of the 4,400 grammes of CO_2 in our present atmosphere. The production of carbon dioxide by the 1,200 million tons of coal annually consumed is but one seven hundredth part of the carbon dioxide already in the air. At any rate, the present increase or decrease of the carbon dioxide in the air is not perceptible by present means of analysis. Any further decomposition of granites, though now slow, due to the comparative small amount of the rock exposed, must absorb a corresponding amount of carbon dioxide from the air, and when the minutest amount more has been absorbed, compared with what has already been accomplished by such decomposed granite, no more carbon dioxide will remain to sustain plant life and the earth will become a dead world. But granites, beside being protected (covered up) from weathering, are also decomposing more slowly because of the comparatively low temperature and low pressure of the atmosphere acting upon them. Since observations have been made, no diminution of the carbon dioxide in the atmosphere has been observed.

[2] Sir William Herschel calculated the total weight of the earth's atmosphere as 11⅝ billion tons. It is really 11⅝ quintillion pounds or 5,800 trillion tons, five hundred times Sir William's figure.

MINABLE COAL RESOURCES OF THE WORLD.

In the following table are given the coal resources of the world, and on this basis it will not be difficult to predict great commercial growth in such nations as China, when once she has had a generation of technical education.

The present production, however, of coal in China, as given for 1910, is only a little over one half that of Belgium.

COAL RESOURCES OF THE NATIONS OF THE WORLD.
(In million tons.)
(From data in report of committee of Twelfth International Congress of Geology, Canada, 1913.)

Nation.	Anthracite.	Bituminous.	Sub-bituminous.	Total.
United States	19,684	1,955,521	1,863,452	3,838,657
North America (except United States)	2,158	284,162	948,454	1,234,774
China	387,464	607,523	600	995,587
Germany	....	409,975	13,381	423,356
Asia (except China)	20,173	152,575	111,251	283,999
Great Britain and Ireland	11,357	178,176	....	189,533
Oceania	659	133,481	36,270	170,410
Europe (except Germany, France and Great Britain and Ireland)	39,718	92,331	21,669	153,718
Africa	11,662	45,123	1,054	57,839
South America	700	31,397	....	32,097
Total	496,846	3,902,944	2,997,763	7,397,553

(Note enormous deposits of anthracite in China.)

From the following table, showing the annual coal production of the principal countries of the world, and the table calculated from it, showing the percentage increase in production by five-year periods, we are able to predict with some degree of certainty a comparatively early exhaustion of the coal resources of the world. The incomplete data for the years succeeding 1910 show no falling-off in this production of coal, but, in fact, it is already evident that the normal five-year increase will be exceeded by 1915.

INCREASE IN COAL PRODUCTION BY FIVE-YEAR PERIODS FROM 1865 TO 1910.
Percentage increase over previous period.

	1865 to 1870.	1870 to 1875.	1875 to 1880.	1880 to 1885.	1885 to 1890.	1890 to 1895.	1895 to 1900.	1900 to 1905.	1905 to 1910.	Average.
United States	21	61	38.5	53.0	38.0	26.0	37.0	44.0	27.0	38.4
World	19	14	19.0	21.5	24.3	13.3	31.6	21.3	23.3	20.8

Thus coal production of the world doubles every 20 years, and of the United States doubles every 11 years.

On this basis, the world's resources will last 250 years, while the United States at her higher increase in production would exhaust her own enormous supply in 110 years.

Furthermore, if we purchase coal lands now in the United States at present values, say 2 cents per ton in the ground, and charge against this investment compound interest at 6 per cent, such unused coal as we may have unmined at the end of 120 years will have cost us $20 per

TABLE OF THE ANNUAL COAL PRODUCTION OF PRINCIPAL COUNTRIES OF THE WORLD.
(In million tons.)
(From Report of Twelfth International Geological Congress, 1913.)

Country.	1865.	1870.	1875.	1880.	1885.	1890.	1895.	1900.	1905.	1910.
Australia	......	......	......	......	......	......	4.01	6.48	6.83	10.00
New Zealand	......	......	......	......	......	......	0.76	1.11	1.41	2.23
China	......	......	......	......	......	......	......	......	......	14.59
India	......	......	......	......	......	......	2.65	6.22	7.92	12.09
Japan	......	......	......	......	......	......	4.84	7.43	11.89	14.79
South Africa	......	......	......	......	......	......	1.40	0.76	3.22	5.50
Canada	......	......	......	......	......	......	3.19	5.09	7.96	13.01
United States	24.79	29.95	48.20	66.83	102.18	141.62	177.59	243.41	351.12	445.81
Mexico	......	......	......	......	......	......	......	......	......	2.45
Great Britain	99.76	112.24	135.49	149.38	161.96	184.59	194.35	228.77	239.89	264.50
Spain	0.45	0.66	0.61	0.85	0.94	1.18	1.77	2.58	3.20	3.55
France	11.84	13.30	16.95	19.36	19.51	26.08	28.24	33.40	36.05	38.57
Belgium	11.84	13.69	15.01	16.88	17.44	20.37	20.41	23.46	21.84	23.13
Germany	28.33	34.88	48.53	59.12	73.67	89.29	103.96	149.79	173.66	221.98
Austro-Hungary	2.03	8.36	13.06	14.80	20.43	26.10	27.25	39.03	40.72	38.00
Italy	......	......	......	......	......	......	0.25	0.48	0.31	0.40
Sweden	......	......	......	......	......	......	0.20	0.25	0.33	0.21
Russia	0.33	0.69	1.17	3.27	4.24	7.00	9.10	14.76	17.12	24.57
Other countries	2.71	4.04	6.26	9.28	12.45	16.89	1.75	2.90	4.55	8.00
Total	182.08	217.81	285.30	339.37	412.82	513.12	581.72	765.92	928.02	1,143.38

ton, or say f.o.b. cars $21, the same figure that White & Hazard paid for coal 100 years ago. Two cent coal carried under the same conditions 250 years would cost about $40,000 per ton. So we see that it is practically immaterial to our posterity whether any coal lasts 250 years or not. Its price would be prohibitive, but of course prohibitive prices can never be maintained.

COALS ARE RESIDUES OF CARBONIFEROUS VEGETATION.

Now, we have 7,400 billion tons of minable coal, but of greatly different varieties. And though capable of producing an enormous number of by-products, the substance of the different coals is not so mysterious if we remember that each variety of coal represents only a different step in nature's slow process of converting the vegetation of the carboniferous era into the fuels so necessary to our modern civilization.

Essentially, therefore, coal was originally wood (cellulose) $(C_6H_{10}O_5)_n$ and resins, now converted in the age-long processes of nature into peat, lignite, semi-bituminous, bituminous, gas coal, smokeless coal, semi-anthracite, anthracite, graphite, diamond, and we might also place carbon dioxide, the raw material from which wood is made, at the head of the series.

It is thus quite remarkable that our fuel coals, near the end of the series, upon burning return again to the air as carbon dioxide, to be converted by photo-chemical processes a second time into vegetation (wood), and thus repeat the cycle of the carboniferous age. But geological ages are made up of cycles of incomprehensible lengths of time. So here when we seek the origin of graphite which is found in the granites of the archaic ages, we can only answer, a previous carboniferous era.

This series of products, with the geological and paleobotanical evidences of its succession, is so reasonable that there can be little doubt that it accurately represents ancient vegetation in the different stages of carbonization in nature's by-product retort.

The earth's crust is such a retort, and the by-products have been saved in the form of asphalt, bitumen, petroleum and natural gas.

We may estimate that over 70 per cent of the weight of wood is lost in being converted to coal, and, according to tests, which follow, possibly one half of this loss was carbon dioxide and the other half combustible gas and oils. This oil and gas, nature's by-products, stored beneath folds of rock strata, constitute our present sources of petroleum and natural gas.

(*To be continued.*)

Submarine and Dreadnought

Which Will Survive? Steam Battleships Are a Century Old, But Submarines Are Much Older

By Willis Fletcher Johnson

SIR PERCY SCOTT has stirred the admiralties of the world as they have not been moved for many years; since, let us say, the epochal duel between the "Monitor" and the "Merrimac." For this great naval authority, one of the highest in the world, practically pronounces big battleships obsolete. The dreadnoughts and superdreadnoughts, costing ten million dollars each, which all important naval powers are building with feverish zeal at the rate of from one to four or five a year, and which are regarded as the criterion of a navy's strength, have been rendered worthless. The submarine has relegated them to the realm of the dodo. It would be folly to build more of them, and those already built may as well be consigned to the scrap yard. Thus Admiral Sir Percy Scott, in re-emphasized repetition, clearly sets forth much of what was said to the same effect by a distinguished Frenchman, Admiral Fournier, some eight years ago.

It must be confessed, parenthetically speaking, that one of Sir Percy's arguments seems strangely unconvincing, particularly when coming from an officer of the British navy. If the building of submarines keeps on, he says, "it will not be safe for a fleet to put to sea." Doubtless not; but when was it ever safe for a fleet to put to sea, in time of war? Not in the days of Salamis, of Actium, of Trafalgar, of Santiago, of Tsu Shima. It was not safe for Nelson to go to Trafalgar, or for Farragut to enter Mobile Bay. But they did not hesitate on that account. Fleets do not put to sea for safety. They go out anticipating and indeed actually seeking deadly danger, but intent upon making the enemy's danger greater than their own. The question is, therefore, not whether submarines are dangerous to dreadnoughts—as of course they are—but whether, in spite thereof, the dreadnoughts are still more dangerous to the enemy.

That, however, by the way; for I am now discussing the relative efficiency of the two classes of vessels. The fact which I wish to recall is that if the submarine should replace the battleship, we should really be reverting to the earlier type, since the submarine considerably antedates the armored steam battleship; though both were devised by the same inventive genius, the later of the two just a hundred years ago. This summer marks the centenary of the first steam warship, which was also the first armored battleship, albeit its armor was of wood, and which, because of its supposed impregnability, may be regarded as the prototype of the dreadnought class. But it is much more than a hundred years since the first submarine vessel was built, tried, and proved to be efficient, yet strangely rejected by a power whose acceptance of it might have transformed the history of the world.

Robert Fulton was the originator, in practical form, of both the submarine and the steam battleship, and also of the torpedo, the last named being essential to the utility of the submarine and indeed suggesting the invention of it. Before his time explosive mines had been used in naval war—note the "Battle of the Kegs" in our revolution—but they were merely set adrift or anchored fast. It remained for Fulton to devise a method of directing their course, and then, because of their dirigible mobility, to name them after the shock-giving fish.

So, too, attempts at submarine vessels had been made before him. William Bourne suggested and described one as far back as 1578; and in 1624 Cornelius van Drebbel is said to have "built a ship which one could row and navigate under water from Westminster to Greenwich; even five or six miles, or as far as one pleased"; but no plans of it have been preserved, and the existing descriptions are too vague to afford any definite idea of its construction. David Bushnell of Connecticut was more successful. In 1776 he built a small vessel shaped like a turtle, which was apparently not to go entirely under the water, but was to float with the crest of its dome just above the surface, its rounded contour rendering it practically impregnable to cannon shot. It was to drift with the tide near enough the enemy's vessel to permit its occupant to thrust an explosive against it. Two practical tests of the craft were made in 1777, against British ships. The first, in the Hudson River, was entirely unsuccessful. The second, in the Connecticut River, resulted in blowing up another vessel than that intended. Bushnell then went to France and continued his experiments, but achieved no further success.

It is altogether probable that Fulton was acquainted with Bushnell's device, since a pretty detailed description of the latter was published in 1795, and his own subsequent invention markedly resembled it in several essential respects. So, too, Fulton doubtless got some ideas of the steamship from former attempts of other men; and so Morse got ideas of the telegraph. The essential circumstance is, however, that Fulton, like Morse, so greatly improved upon the plans of his predecessors as to succeed where they failed; or where, at any rate, they did not succeed.

The description of Bushnell's vessel was published in France in 1795. Two years later Fulton proposed to the French government the construction of what he called a "Mechanical Nautilus," to destroy the British fleet. There arose at once, however, a serious difficulty over a matter of law. Such a device was regarded as contrary to the rules of civilized warfare, and those operating it would therefore be outlaws and not entitled, in case of capture, to the immunities of prisoners of war. In order to secure protection, if possible, for those who should man the submarine, Fulton stipulated that the French government should make it known that if they were put to death it would retaliate fourfold upon the British prisoners in its possession. To this the French government demurred, largely on the very practical ground that there were more French prisoners in the hands of the British than British in the hands of the French, and that therefore in a contest of reprisals the French would suffer most. So it declined to give commissions in its navy to the crew of the "Nautilus," and finally rejected the whole scheme.

The next year, 1798, Fulton renewed his proposals. That was the year in which Nelson destroyed the French fleet at the Nile, when, if ever, France needed aid against the sea power of Britain. He made known the general principles of his scheme. The submerged boat was to be driven by a screw propeller, operated by hand power. It would have a speed of several miles an hour and would be perfectly dirigible, and could remain entirely under water for an hour or more. A French government commission examined into it, pronounced it a work of genius, and recommended its acceptance. Had this recommendation been promptly and energetically acted upon, Bonaparte might have conquered England and the history of the world might have been changed. But it was not acted upon. On the contrary, nothing at all was done.

Fulton, however, persevered. He proceeded with the building of a submarine, and on July 24th, 1800, launched it in the Seine at Rouen. Five days later the first practical trial was made. Fulton and two other persons went down in the boat and remained submerged for eight minutes. The second time they remained down for seventeen minutes, in twenty-five feet of water. The boat was twenty feet long but only five feet in diameter, so that the men could not stand upright. But it was proved that it could sink and rise again, and be propelled and steered under water.

A few days later Fulton took the vessel to Havre and experimented with it in the harbor. He repeatedly remained submerged at a depth of fifteen feet for an hour or more, sometimes alone and sometimes with two passengers. Also, he successfully discharged a torpedo against a cask used as a target. On September 12th he left Havre for La Hogue, steering boldly across the open sea, and making four and a half miles an hour. On September 16th he remained below the surface for six hours at once, drawing supplies of air through a tube, the end of which floated upon the surface. Near Isigny he attempted to approach some British ships, but was unable to do so. He made the trip to La Hogue, however, more than seventy miles, in safety, and thus abundantly demonstrated the navigability and the seaworthiness of the little craft.

From La Hogue he conveyed the boat overland, on a cart, to Brest, where he launched it again and made further highly successful experiments; or, rather, demonstrations, for the thing had passed the merely experimental stage. An old sloop was set as a target, and he demolished it completely with a single torpedo, at the first attempt. But at this time Moreau was vanquishing Austria and Bonaparte was conquering Italy, and the Directory underrated the value of sea power compared with triumphs on land. So no terms satisfactory to Fulton would be considered, and the great inventor finally gave up his efforts. He tore the hull of the "Nautilus" to pieces, broke up the machinery, and left nothing which could give anyone a hint as to how to reconstruct the vessel. He retained detailed drawings of all parts of it, but he refused to show these to the French government, and took good care to keep them where that unappreciative body could not get hold of them. He lost some thousands of dollars which he had spent from his own pocket on the enterprise. But France lost her only chance of gaining the mastery of the sea and of conquering her island foe. And a little after that came Trafalgar.

Fulton then turned his attention from ships of war to ships of commerce, and seven years later revolutionized navigation with the "Clermont." But when our second war with Great Britain came on, he set about applying his great invention of steam navigation to the navy. Obviously, the first requisite of a steam warship was that it should be so armored that the engine would be safe from cannon shot. The paddle wheels must also be protected, which in the "Clermont" and other steamers were openly exposed. Strangely enough, he did not attempt to apply the screw propeller, which he had devised and used years before, but left that for John Ericsson in after years. Instead, he designed a craft which somewhat resembled a catamaran, and somewhat, also, a single very broad hull with a big well-hole in the center. It resembled a catamaran in having two parallel keels. But the two hulls were connected at bow and stern, into a single bow and a single stern, to a point below the water-line. Thus the single huge paddle wheel in the central space between the two hulls was protected at bow and stern from raking fire, as well as at the sides. The ship was simply a broad oval floating battery, with engine below the water-line and wheel in a central well-hole.

I have spoken of this as an armored vessel. It was. The sides were of solid oak timber, 5 feet thick. They were thus as impervious and impregnable to the cannon shot of those days as are the 10 or 12-inch steel plates of a modern dreadnought to the projectiles of our time. The vessel was to be heavily armed, too, with what were for that time big guns. It was to carry twenty

100-pound Columbiads; so called by Fulton in honor of his friend Joel Barlow's epic, "The Columbiad." These were to be placed two at the bow, two at the stern, and eight on each side. Moreover, it had several similar guns which were to be fired below the water-line, as torpedoes are now discharged; Fulton's last patent being for such ordnance. Of course, cannon shots under water would not carry far; but when vessels were only a few feet apart, or actually touching sides, as often happened in those days, such fire would be tremendously effective.

This vessel, named by Fulton the "Demologos," was designed in 1813. Congress in March, 1814, authorized its construction, and Fulton set to work upon it promptly. The keel was laid on June 29th, 1814, in the shipyard of Adam and Noah Browne, on the East River, New York, and on October 29th the ship was launched. It was 167 feet long and 57 feet broad, and had 12 feet depth of hold. Its engines were of 120 horse-power. Fulton promised that it would make four or five miles an hour, but it actually made 6.4 miles, and despite its clumsy shape was very easily steered. As it drew only 11 feet, it could traverse most navigable waters; certainly going wherever a line-of-battle ship or even a big frigate could go. Fulton modified its armament, however, giving it thirty long 32-pounders instead of the twenty 100-pounders which were at first intended. The total cost of the ship was about $240,000.

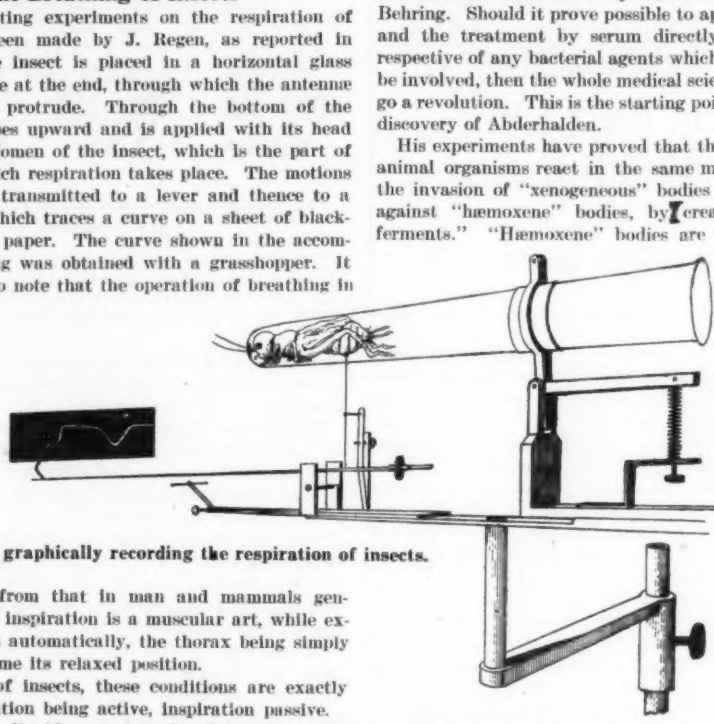
The trial trip was not made until June 1st, 1815. On July 4th of that year it made the 53-mile trip to Sandy Hook and back at an average speed of 6.4 miles an hour; but as the war with Great Britain was ended, it was not needed for service. So it was laid up at the Brooklyn navy yard as a receiving ship, and upon Fulton's death in that same year it was renamed after him. It was its inglorious fate, on June 4th, 1829, to be destroyed by an accidental explosion, which also cost the lives of twenty-five men. It may be added that the British Admiralty also began, shortly after the building of the "Demologos," the construction of a steam warship, a sloop named the "Congo." But because of the ending of the war with America it was altered into a sailing vessel, and the engine which had been made for it was used for pumping at the Devonport dockyard.

The interest which Fulton's warship excited abroad was very great, though the public was not well informed. All sorts of extravagant tales about the "Demologos" got abroad and were credited. Perhaps the most picturesque was that which was published in the *Evening Courant* of Edinburgh, Scotland, at the end of August, 1815—an account which was given seriously, from a correspondent who had taken pains to secure full and accurate information. It described the vessel as 300 feet long and 200 feet wide, with walls 13 feet thick, of alternate layers of oak and cork! It carried four 100-pound and forty 42-pound guns, and had, in addition, a device for discharging against an enemy attempting to board, 100 gallons of boiling water a minute! But the crowning equipment of all was a mechanism which "brandishes 300 cutlasses with the utmost regularity over her gunwales, works also an equal number of heavy iron pikes of great length, darting them from her sides with prodigious force, and withdrawing the same every quarter of a minute!"

But perhaps even such a vessel and its equipment would not have seemed as amazing and as formidable at that time as would one of the ships which are familiar commonplaces in our time, could it have been exhibited then.

The Breathing of Insects

Some interesting experiments on the respiration of insects have been made by J. Regen, as reported in *Umschau*. The insect is placed in a horizontal glass tube with a hole at the end, through which the antennæ are allowed to protrude. Through the bottom of the tube a pin passes upward and is applied with its head against the abdomen of the insect, which is the part of the body in which respiration takes place. The motions of the pin are transmitted to a lever and thence to a tracing point which traces a curve on a sheet of blackened (smoked) paper. The curve shown in the accompanying drawing was obtained with a grasshopper. It is interesting to note that the operation of breathing in insects differs from that in man and mammals generally. In man inspiration is a muscular art, while expiration follows automatically, the thorax being simply allowed to assume its relaxed position.



Instrument for graphically recording the respiration of insects.

In the case of insects, these conditions are exactly reversed, expiration being active, inspiration passive.

When carbon dioxide was introduced into the tube, the insect became unconscious and all motion ceased. If this state of affairs is allowed to continue for some time the animal dies. If, on the other hand, air is again admitted after a moderate length of time, it revives.

It was observed that in decapitated insects breathing was considerably slowed down, so that it appears that the brain has an influence upon the rate of respiration.

The Abderhalden Reaction for the Diagnosis of Disease

Communication from our special European agent.

The fundamental discoveries of sero-therapeutics made by Robert Koch twenty years before opened a new epoch in the history of medical science. Koch proved that the human as well as the animal organism reacts against invading bacteria, "xenogeneous" bodies as science calls them, by producing protective substances. The object of these protective substances is to annihilate the bacteria in the blood. Generally these substances show certain characteristics that make it easy to ascertain their presence. Thus it was found possible to recognize certain infectious diseases at an early stage by an examination of the blood. But the discovery of Robert Koch has not only shown the way to a rapid diagnosis of the nature of the illness, it has also enabled us to fight the disease with the aid of the protective, or better, annihilating substances produced by nature itself. Animals are vaccinated with the bacteria provoking some special illness; these animals sicken and form in their blood certain protective substances. The blood of these animals, impregnated with these substances, is then introduced as "serum" into the veins of human beings infected by a like disease. Thus the natural weapons of the body for fighting the illness are being artificially strengthened. For certain diseases the curative results thus obtained are positively marvelous, for instance, in the case of diphtheria, with the "serum" invented by Behring.

Thus, medical science had found entirely new ways by the methods discovered by Koch and perfected by Behring. Should it prove possible to apply the diagnosis and the treatment by serum directly to diseases, irrespective of any bacterial agents which may or may not be involved, then the whole medical science would undergo a revolution. This is the starting point of the inspired discovery of Abderhalden.

His experiments have proved that the human and the animal organisms react in the same manner as against the invasion of "xenogeneous" bodies or bacteria, also against "hæmoxene" bodies, by creating "protective ferments." "Hæmoxene" bodies are those substances which, while created by the organism itself, do not enter into the blood under ordinary conditions of normal health.

Every organ of the animal organism has its own particular function; in order to properly carry out this function, it is provided with a chemical and molecular constitution of its own. The liver-cells, whose functions differ entirely from those of the lung-cells, are also constructed chemically on quite a different basis. But the blood must always remain homogeneous, if it is to fulfill its life-preserving task. Therefore, the different organs must pass on to the blood the dead cells, used up by the process of life, and their own products of assimilation and disassimilation in a chemically homogeneous form. To do so, every organ performs extremely complicated chemical decompositions, each according to its own peculiar system.

If any one organ gets out of order, such disarrangement seems to affect first of all this process of decomposition. Parts of insufficiently decomposed cells or of imperfectly decomposed products of the assimilation and disassimilation enter the blood and disturb or even menace its functions. The organism at once sets about to produce protective ferments capable of finally decomposing the cell-constituents of the diseased organ, "digesting" them, and thus rendering them innocuous.

It is the great, the undying merit of Abderhalden to have discovered the formation of these protective ferments, and his merit is the greater because his discovery was not an accident, but the result of many years of serious and painstaking research.

The discovery made by Abderhalden proves that the organism diagnoses its own illness automatically. It remains for us to learn to understand its language. And this diagnosis has the enormous advantage of being infinitely more exact, more rapid, and more certain than all that human art can ever attain.

Each organ contains special ferments within its cells. These ferments are in the most subtle way attuned to the molecular constitution of the particular cell-substance of the respective organ, and show complete indifference toward the cells of other organs. Under normal conditions these cell-ferments are only found at the particular place where they have to accomplish their task, i. e., within the cell itself. As soon, however, as there appears in the blood a substance still showing the "cell-characteristics," the corresponding ferment also appears in the blood. Experiments have proved that the protective ferments can often be found in the blood only a few hours after the first disturbances in the function of the organ. The "police-service" of the organism works with perfect accuracy. These ferments are, as has been said already, extremely characteristic in their effects, decomposing only the cell-parts of the organ to which they belong. Therefore, by the methods elaborated by Abderhalden, we have the possibility of diagnosing organic disorders at their very first stage and this, as shown by experiments with chemical substances, very often after only a few days or even hours, while under ordinary circumstances, weeks and months, even years, may elapse before the effects of the disorder have grown to the proportion of pathological symptoms. An imaginary example, anticipating the expectations placed upon Abderhalden's discovery, will show this more clearly.

Someone comes to his doctor complaining of strong and continuous headaches accompanied by insomnia. The examination reveals no symptom permitting a definite diagnosis. The doctor takes a small quantity of blood from the patient and distributes it in a number of test-tubes. Into each test-tube is then put a piece from a different organ of the animal used for the control: a piece of brain matter, a piece of liver, of the lung, of the kidneys, of the heart, of the thymus and of the thyroid gland, as the patient's headaches may have the most various causes. Controlling the test-tubes twenty-four hours later it is found that lung, liver, kidneys and heart have not been altered by the serum but that the brain and the thyroid gland show signs of being decomposed. This proves that the blood of the patient contains ferments from the brain and from the thyroid gland. The presence of these ferments in the blood indicates that the functions of these two organs are disturbed, thus introducing into the blood cells insufficiently decomposed. The secretion of the thyroid gland being of extreme importance for the proper function of the brain, the positive reaction of this part of the experiment shows that the disturbances of the brain cells are caused by the thyroid gland supplying the brain insufficiently with this necessary secretion. Thus the doctor knows exactly where his treatment has to set in.

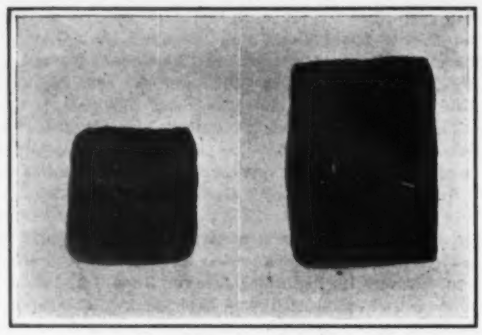
One must know the difficulties that beset the timely and correct diagnosis of disturbances of the internal organs, more especially when it is a case of functional disturbances as yet not showing any alterations of the respective organ itself, to be able to appreciate the overwhelming importance of this discovery for the curing of disease.

This importance accounts for the fact that medical authorities of universal repute have felt it their duty to draw particular attention to this discovery. Should the experiments that are being conducted in all the great centers of Europe prove the theory of Prof. Abderhalden to be universally valid, based as it is already on a great number of definite facts and experimental results, then medical science enters upon a new epoch and the name of the German scientist Abderhalden will have its indelible place in the golden book of humanity's greatest men.

It is too early to form any final conclusion as to the ultimate success and scope of the methods initiated by Abderhalden, but indications are exceedingly favorable in relation to a number of diseases, especially sarcoma (cancer), and certain troubles of the nervous system and brain.

Chinese coins in the collection of Horace Fletcher, San Francisco.

1. Coin of Sung, B. C. 2257; 2, Coin of the Chau, or Chow Dynasty, B. C. 245; 3, 4, 5, and 6, Four coins of the Han Dynasty, A. D. 9.



Egyptian brick money.

Said to have been dug up in Babylonia, purchased in Constantinople in 1885 and submitted in 1898 to Mr. Hormuzd Rassam, assistant to Sir Henry Layard, who pronounced them to be genuine, very ancient, and possibly unique. They had evidently once been jeweled, and were probably taken from some sepulchre. In A. D. 1171, the Fatimite caliphs of Egypt issued similar coins of porcelain and glass, specimens of which are to be found in most of the great coin cabinets of Europe. They are mentioned in Del Mar's "History of Monetary Systems."

Chinese coins in the collection of Horace Fletcher, San Francisco.

7, Half Tael, B. C. 178, Paun Liong; 8, Another of same date; 9, Another dated B. C. 139; 10, Five Chue or Dots, B. C. 139, Ung Chue; 11, Fifty Chue, A. D. 9, Hai-Tshuen; 12 to 18, Seven coins of same period of the "cash" type.

The Evolution of Coins and Coinage Mechanisms

By Alexander Del Mar

The oldest coins (from cuneus, a punch) are assigned by Herodotus to Lydia and by Mionnet to Persia; but if the word is intended to cover cast or hammered metallic money, then coins are 12 or 15 centuries older than the Persian darics; for we have Chinese bronze "knife" coins of Sung, 2257 B. C. inscribed "Tong King Ho," or good for gold, also numerous allusions to metallic money, not weights, but "current money with the merchant," (Genesis xxiii, 16) as the Hindu ramatenkis and siccas, Babylonian brick money, Hyksos ring money (baugs), cowries, and other very ancient testimonies.

These evidences prepare us to trace the metals from which these moneys were made.

The oldest gold mines for which we possess literary evidence are the auriferous of Hyperboria (Thibet) in Herodotus; the oldest by inference are the alluvions of India; the oldest by inscriptions and modern survey are the Bisharee alluvions of Egypt, nineteenth century B. C. A comparison of all the evidences leads to the conclusion that the knife money of China is the oldest of all moneys, the ramatenkis of India, bricks of Babylon, ring money of Egypt, and the punched coins of Asia Minor following successively, in the order of time.

Between the rude issues of Asia Minor and the most perfect coins of the Greek States is an interval of three centuries, during which all that is known, or probably ever will be known, in beautifying a steel die was achieved. So far as design is concerned, the Greek coins were simply perfect. No modern coins can compare with them in beauty.

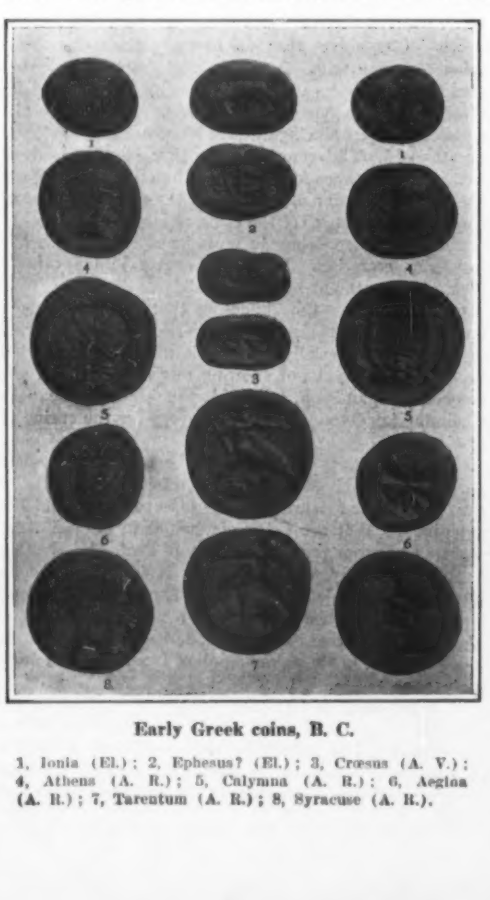
Among the early Roman coins, the ace or æs, Æ, was of cast bronze, the others were of gold, AV, for aurum, or silver, AR, for argent. Though mostly designed by Greek artists, they betray a decadence of the fine arts. The daggers of Brutus and Cap of Liberty on his silver coins are especially interesting. They were struck in the field near Philippi, where he met his fate. On the other hand, the Roman coins evince a practical improvement in the art of coinage; for the designs are surrounded by a line of dots, or a raised circle, to guard against clipping: a Greek invention, popularized by the Romans.

Roman coins of the imperial period are of the greatest historical interest. From the sad and furrowed face of Julius to the self-satisfied effigy of Domitian, extends an interval of 100 years, filled with the most noteworthy events in the history of Rome.

With the removal of the capital to Byzantium (Constantinople) began that rapid decline in the arts characterized by the "Dark Ages" and feudal system; the coinage faithfully reflecting it: for the arts cannot flourish in serfdom or slavery.

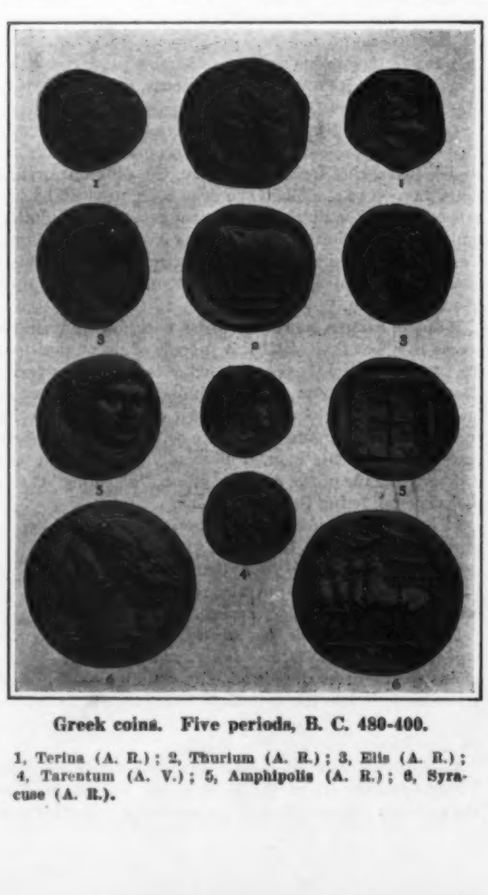
This decadent period lasted until the Arabian Renaissance of the twelfth and Italian Renaissance of the fourteenth century afforded, through the agency of commerce, encouragement to the arts.

The discovery of America and its influence in ameliorating the social condition of Europe is the greatest event in the history of the world. In little more than



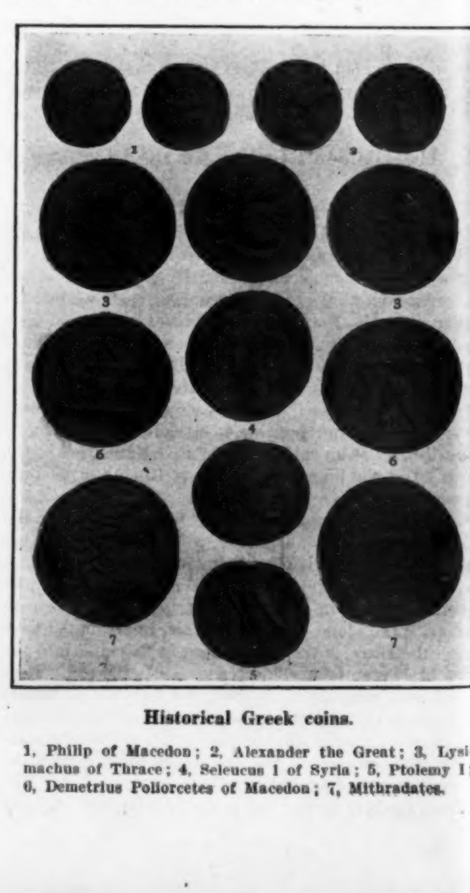
Early Greek coins, B. C.

1, Ionia (El.); 2, Ephesus? (El.); 3, Crœsus (A. V.); 4, Athens (A. R.); 5, Calymna (A. R.); 6, Aegina (A. R.); 7, Tarentum (A. R.); 8, Syracuse (A. R.).



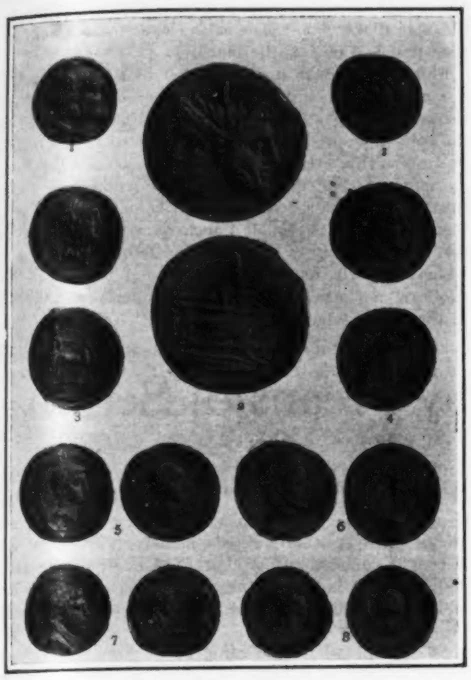
Greek coins. Five periods, B. C. 480-400.

1, Terina (A. R.); 2, Thurium (A. R.); 3, Elis (A. R.); 4, Tarentum (A. V.); 5, Amphipolis (A. R.); 6, Syracuse (A. R.).



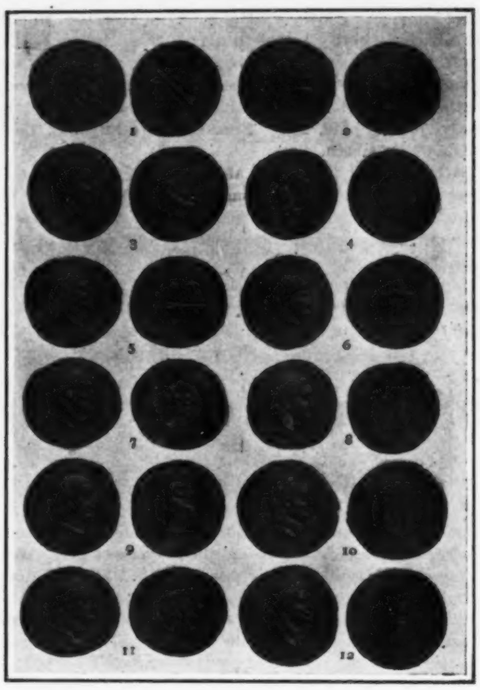
Historical Greek coins.

1, Philip of Macedon; 2, Alexander the Great; 3, Lysimachus of Thrace; 4, Seleucus I of Syria; 5, Ptolemy I; 6, Demetrius Poliorcetes of Macedon; 7, Mithradates.



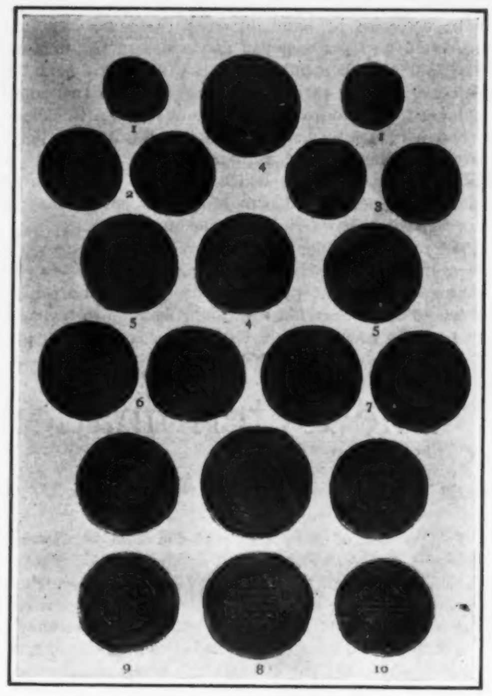
Roman Republican coins.

1, Denarius (A. R.); 2, As (A. E.); 3, Sulla (A. V.); 4, Julius Cæsar (A. V.); 5, M. Antony and M. Lepidus (A. V.); 6, Octavian (A. R.); 7, Sextus Pompey, Pompey the Great and Cneius Pompey (A. V.); 8, Brutus (A. R.).



The twelve Cæsars.

1, Julius Cæsar; 2, Augustus; 3, Tiberius; 4, Caligula; 5, Claudius; 6, Nero; 7, Galla; 8, Otho; 9, Vitellius; 10, Vespasian; 11, Titus; 12, Domitian.

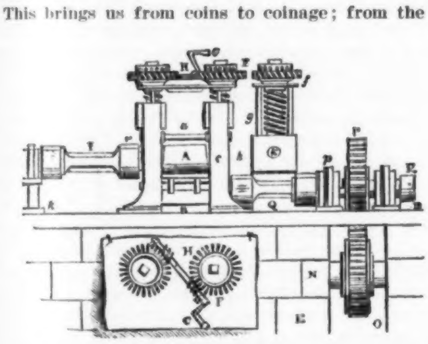


Anglo-Saxon coins.

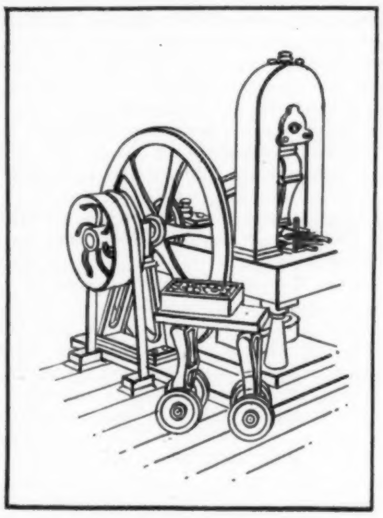
1, VIII Century Sceat; 2, Offa of Mersia; 3, Aethelberht of East Anglia; 4, Wigmund, Archbishop of York (gold); 5, Alfred of Wessex; 6, Halfdan; 7, Olaf Quaran; 8, Edward the Elder; 9, Aethelred II; 10, Edward the Confessor.

a single century, 1540-1650, were made nearly all the great discoveries in science and art which afford the basis of our existing industries, scientific attainments, and mechanical inventions. Here again the coinage reflects the revolution. Compare the pennies of the Normans with the Italian effigies of Mary and Elizabeth; or the groats of Henry VI with the guineas of Charles II.

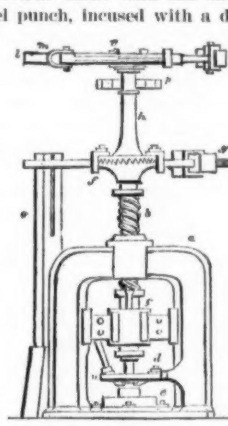
This brings us from coins to coinage; from the fine arts to mechanisms. Leaving cast coins, and brick and ring moneys, out of view, the ancient method of making a coin was to hammer out a thin plate of metal, cut it into circular disks with the shears, and strike it with a steel punch, incused with a design; the blow



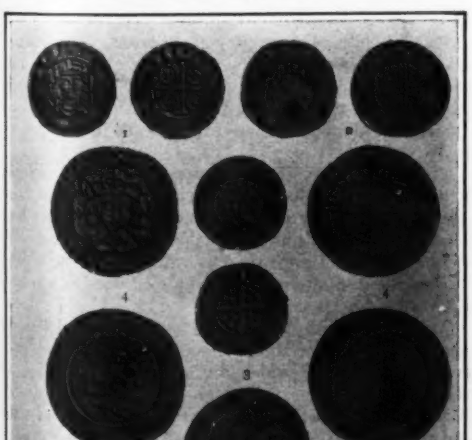
Rolling mill for "flatting" metal for coining.



Embossing press for stamping the designs on coins.

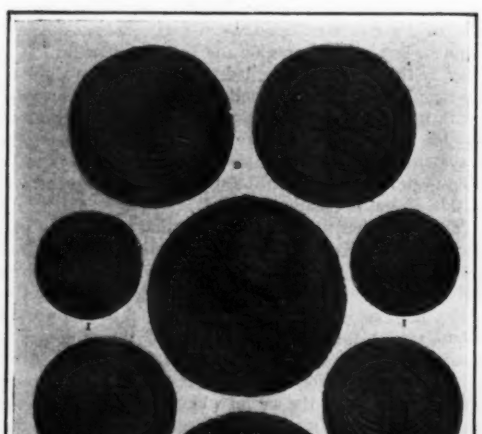


Press for punching coin blanks.



English silver coins.

1, William I, penny; 2, Henry I, penny; 3, Edward I, penny; 4, Henry VI, groat; 5, Henry VII, shilling; 6, Elizabeth, sixpence; 7, Charles I, half crown.



English gold coins.

1, Henry III, gold penny; 2, Edward III, noble; 3, Henry VI, angel; 4, Henry VII, sovereign; 5, Charles II, guinea.

English historical medals.

1, Mary, Queen of Scots, by Primavera; 2, Elizabeth, Badge—Defeat of Armada.

being delivered by hand, in much the same way that we would now put a punch mark upon a metal plate. The coin was then finished with a file. The next improvements were to roll the metal between two small cylinders, so as to produce a plate of uniform thickness, and to cut it into disks with a punch. At this point invention stopped and retrograded for practically a thousand years, during which time the population of Europe declined from 120 to 40 millions, and commerce retrograded to barter, or to payments in kind.

The metallic plunder of America was the tremendous lever that converted the decay of Europe into an era of progress. In the fifteenth century a skilled coiner, of whom there were but few, might be able to turn out by hand 50 or 60 coins a day; a result totally inadequate to cope with the vast quantity of treasure, chiefly silver, that shortly began to arrive from America. To multiply coiners was to multiply forgers; and thus the coining machine became a necessity of State. A laminating mill and screw coining press was invented in Italy, 1547; Spain, 1548; France, 1553; England, 1561, reign of Elizabeth.

After several trials and abandonments the mill and press were established permanently under Charles II, whose golden guineas, struck in 1662, were the first regular issues of machine coins made north of the Channel.

The laminating machine is sufficiently explained in the illustration showing the rolling mill (page 121), where a sheet of metal is made to pass between rollers *A* and *B*, which reduce it to a uniform thickness. Circular disks, exact size of the coin to be made, are then punched out by the machine.

Finally the disks are submitted to a double punch, the upper one being a steel die incused with the obverse, and the lower one incused with the reverse of the coin to be produced. When subjected to this double process, with a pressure of 50 to 75 tons, the inert disks, no matter what their commercial value, are transformed into money, with the legal value conferred upon them by law. The double punch constitutes the seal of the State; and it is that, and the mint law behind it, which converts metal into coins and coins into the "dollars" or other monetary denominations described in the legal-tender law.

The Determination of Plant Relationship by Means of Serum

A Means of Investigating Origins by a Comparison of Albumens

The problem of every system of classification, whether zoological or botanical, is such arrangement of the organisms that their historical development from their origin down shall be presented as clearly as possible. The classification of animals and plants in a natural system is to some degree the indication of the ratio of relationship of the individual species to common ancestors. As, however, all judgments in regard to the construction of a system of classification rest upon subjective perception of similarity and disparity between the objects contemplated, various attempts have been made of late to use similarities other than those formerly held to be important as a basis for the natural system, or as the reason for changes in it, or even for overthrowing it. In any case its divisions are capable of change, and it is only the older botanists who looked upon the system as a fixed series of pigeon-holes for the accommodation of their discoveries in the vegetable kingdom. This elder generation, though, has passed away. The history of evolution teaches that there is a progressive differentiation. Far greater uncertainty exists, however, in the classification of the individual groups, because consanguinity cannot always be traced with certainty on account of morphological conditions, and so there is no doubt that even to-day we are still far from being able to regard our "natural" systems as final.

The necessity of making every possible effort to place systematology, especially that of the higher plants, on a better basis has led to investigations with the aid of the serum diagnosis. In discussing in the *Umschau* this method of determining the classification of plants, Dr. Kurt Gohlke says:

"The methods of this diagnosis by means of serum have become very important of late years, for the most widely separated branches of science. Uhlenhuth has been able to prove not only that the blood of one animal can be distinguished from that of another by the aid of serum reactions, but also that the relationships of the different kinds of blood can be determined. Especially interesting are the results which Uhlenhuth, Wassermann, and Stern were able to prove concerning the connection between human blood and that of the various species of apes, thus establishing 'consanguinity' by means of sero-biological methods.

"Most interesting for the natural sciences was the proof offered by Kowarski that vegetable albumen also could be determined by means of a diagnosis with serum. Various experiments were made on this point, one of which was that of Magnus and Friedenthal, who were able to show a relationship between truffles and yeast fungus."

Any discussion of a natural relationship presupposes, however, a preliminary investigation as to whether this relationship of the albumens is to be regarded as equivalent to the natural relationship. When we consider the important part played by chemical processes in the life of every organism, it can probably be assumed with certainty that the close or distant relationship between two organisms in the great ancestral stock of the organic kingdom will also be evident in their chemical properties. This natural relationship must also of course be evidenced in the structure of the highly concentrated albumen which is so closely connected with the vital functions. The composition of these albuminous substances is not known. At any rate it is not possible, at least by chemical means, to determine them so exactly that this determination would suffice for the purposes of classification. It has, however, become possible, as has been said before, to secure a differentiation of albumens by the aid of serological investigation.

"Before, however, I enter into the particulars of the various methods in question," continues Dr. Gohlke in pursuing his subject, "I should mention that the utility of these methods for special botanical purposes had to be proved. The proving of this utility became absolutely necessary after the publication of the experiments previously made, some of which were decidedly fragmentary and were not undertaken for the purpose of systematic grouping in families, while others yielded contradictory results.

"To this end, four methods were tried, namely, precipitation, the binding of the complement (Wassermann's reaction), anaphylaxis, and conglutination."

For the botanist probably anaphylaxis (hypersensitiveness) had to be excluded as a matter of course. The method of using it is the following: "If foreign albumen is introduced, as by inoculation, into the body of a warm-blooded animal, there is developed after awhile, and after the introduction of a certain amount of the inoculating material, a peculiar sensitiveness. This hypersensitiveness is evidenced in this way: that the animal thus treated reacts with violent symptoms of illness, and often dies in a few minutes if inoculated again with the same solution of albumen, even when this contains no poison. The condition called anaphylaxis has, therefore, a strictly specific effect, that is, rabbits previously treated with horse serum are only hypersensitive to this and not to goat or bovine serum. Relationships, though, can be recognized."

As the albuminous solutions with which botany is concerned are obtained almost entirely from the seed of plants, and as the solutions vary greatly in the amount of albumen they contain, each depending on the albuminous content of the respective seed, an exact judgment as to the experiments made by anaphylaxis is, therefore, difficult. Any positive judgment becomes impossible when it is remembered that a large amount of other substances, some poisonous (as alkaloids) are contained in the solution, which substances must be injurious to the animal. Besides, the undue proportion of deaths among the animals used for the experiments condemns the use of the method in proving relationships in a botanical classification.

"Without going into the method of binding the complement, which is that of Wassermann's reaction used in the investigation of syphilis," says our writer further, "I wish to reject it as also unsuitable for the present purpose. The results of this method are extremely exact and clearly defined, but are too specific for the end in view. It is easy by the aid of this method to determine the albumen (antigen) used for the inoculation, the reaction also appears if the albumen belongs to another closely allied species, but it fails for more distant relationships. For a system of classification, though, it is important to be able to prove very distant relationships, consequently to obtain a remote reaction."

The two other methods, precipitation and conglutination, are well suited for obtaining reactions showing connections. Precipitation is extremely simple, and requires only an antigen and an immune serum produced by this antigen. This immune serum is obtained as follows: An albuminous solution (as an extract of the albumen of beans) is injected into the circulation of a rabbit. After a number of injections, when the rabbit's blood is drawn off and coagulates, the serum which separates forms the immune serum. This immune serum has the characteristic that in clearly defined gradations of dilution up to a certain degree it gives a precipitate with the antigen used for injection, that is with the bean albumen, but it does not give a precipitate with an albuminous solution of other origin. This assertion, however, cannot be pushed too far. This specific reaction appears only when the albuminous solutions, that is, the albuminous solution used for injection and the second albuminous solution, do not come from related seeds. Thus, for instance, an immune serum produced by means of a papilionaceous plant, the lentil, reacts upon all other papilionaceous plants and further upon the related rose and crowfoot families, but, on the other hand, it does not affect a single plant of another more distantly allied family (as the grasses). The first experiments for a reaction showing relationships were made by this method. Besides its simplicity, precipitation has for botany another great advantage over other methods, namely, it brings to view not only connections with other families of the same series far beyond the family with which it starts, but what is still more important it shows connections with other series also.

"Conglutination," according to Dr. Gohlke, as he explains how to use the immune serum in testing the albumen of seeds, "is somewhat more difficult in its technical details, as when it is employed, the serum of a ruminant (for instance, bovine serum) is used. If in the method by precipitation we had to do with the graduated dilution of the albuminous solution in various test tubes (1 to 200, 1 to 400, etc., up to 1 to 50,000), in the method by conglutination the amount of albumen in the extract is constant in all the test tubes (the dilution might be 1 to 200), and the variation is only in the amount of immune serum that is added to it. The proportion of serum in this method is exceedingly small (0.08, 0.02, 0.01, 0.005 cubic centimeter in test tubes Nos. 1 to 4, while in the precipitation method each glass receives 0.1 cubic centimeter). In the conglutination method the extract and the immune serum are combined at 37 degrees in two hours in the incubator, that is, the extract is sensitized. After this period of time, fresh bovine serum is added in the proportion of 0.4 cubic centimeter for each tube. There then appears in those tubes where a large amount of the immune serum is present a clearly evident conglutination, that is, a flocculent precipitation, which is entirely different from the deposit of the precipitation method. This characteristic clumping rests on this fact, that bovine serum contains some substances which are called conglutinins and which produce conglutinations. The advantages of this method consist in the ideal sensitiveness which essentially exceeds that obtained by precipitation, and in the small amount of immune serum it is, on this account, necessary to use. This permits hundreds of experiments to be made in all directions in the vegetable kingdom from one original immune serum. A necessary condition is, however, that the immune serum should be of highest potency."

This brings us to a very important point. The amount of albumen contained in the extracts of albumen gained from the seed of plants varies so greatly that it is much more difficult to immunize the rabbit than it is to immunize blood in analogous experiments in hygiene or zoology.

The seeds in Dr. Gohlke's experiments were crushed to a very fine meal in mortars or in the mill, which work demanded naturally extreme cleanliness. The meal was then mixed in definite proportions with a solution of common salt, and some time was allowed for extraction. The solutions of albumen thus obtained were cloudy and were filtered until clear.

There appeared during this process the collateral phenomena characteristic of vegetable seed. Various substances were found which are supposably injurious to the animal if injected, and which would even cause death. Although the most varied experiments were made for the removal of these injurious substances, these experiments were not always successful in getting rid of all of them. Consequently, in discussing the utility of the albumens to be used in the experiment, a preliminary investigation as to whether these injurious substances are present in the albumen must be assumed. On this account the preparation of the extract varies according to the specific character of each seed.

Occasionally a potent immune serum is obtained after three or four injections, 10 cubic centimeters being used for each injection. There are, though, cases in which no immunity was attained after frequent injections. The reason for this is either in a distinctive peculiarity of the animal, for Uhlenhuth mentions that, for instance, of ten animals treated at the same time with albumen only one yields a potent immune serum, or else the difficulty arises from too small a content of albumen in the extract. This

latter trouble appears with relative frequency, because many seeds contain hardly any discernible albumen, as the very small seeds of the willow.

To get the immune serum the animal is bled, the coagulated blood is centrifuged, and the serum thus obtained is preserved.

"Whoever after this undertakes to make researches as to relationships by means of serum reactions," pursues the author, "must constantly bear in mind that there are many pitfalls which can only be avoided by the greatest caution. But the person who has worked by these methods for some time soon gains an exact knowledge of the reactions and certainty in judging them, so that he can enter upon the researches with absolute confidence. This confidence is further strengthened by experiments with seeds of unknown origin and control experiments both with normal rabbit serum, and pure extract, etc.

"Diagnosis by means of serum has proved its utility both for methods and for the purposes of classification. A large number of families have already been investigated as to their systematic position, and further researches are being made under Prof. Dr. Mez in the Botanical Institute of the University of Königsberg. It would take us too far to give a detailed report of the very interesting results."

The author then refers to some books by himself and others on the subject, all published in 1913. His own work is on "The Utility of Serum Diagnosis for Proving Doubtful Relationships in the Vegetable Kingdom;" one by Gohlke and Mez is "Physiologico-Systematic Researches upon the Relationships of the Anglo-Spermæ;" and by Lange, "Sero-Diagnostic Researches upon the Relationship within the Plant-Group of Ranunculaceæ."

It should be mentioned that in no case have the researches made up to now resulted in a contradiction of the determinations which have been deduced from the forms of plants. On the contrary, serum diagnosis offers a method by which we can advance in the difficult field of the historical investigation of origins. It is true that a relationship of the plants is not directly proved, yet the determining of a connection between the albumens gives an important indication of relationship. This is a great advance which yields valuable conclusions for the history of the main stock, and thus the importance of this method for the development of science is made plain. Consequently the value of serum diagnosis for the proof especially of doubtful relationships in the vegetable kingdom cannot fail of recognition.

The Meeting of the British Association in Australia

By the English Correspondent of the Scientific American

The eighty-fourth meeting of the British Association, which has just commenced, promises to be a great success. The Commonwealth government made a subsidy of $75,000 in aid of the expenses, besides publishing a Federal Handbook of 600 pages for gratuitous distribution to the visitors, some 350 in number. In addition, the premiers of the various states have secured free railway facilities, and have taken an active part in promoting schemes of reception and hospitality.

The holding of the meeting in Australia makes, naturally, a strong appeal to Englishmen. One of the greatest of British discoverers, Capt. James Cook, whom tardily enough, we have recently commemorated by a statue, added Australia to England's possessions, and its colonization was the ultimate result. In 1788 the first settlement was formed, and thirteen years afterward Capt. Matthew Flinders began his exploration of the shores of the island, "undertaken for the purpose of completing the discovery of that vast country," and carried out in H.M.S. "Investigator." The original name was Terra Australis, used by the Dutch themselves until some time after Tasman's second voyage in 1644, subsequently displaced, however, by the term New Holland, though this was applied to part only of the region. Flinders remarks that so soon as New Holland and New South Wales were known to form one land, a general name was advisable, and therefore he ventured upon the readoption of the original Terra Australia. "Had I," he adds, "permitted myself any innovation, it would have been to convert it into Australia, as being more agreeable to the ear, and an assimilation to the names of the other great portions of the earth."

Reaching Melbourne on August 13th, Prof. William Bateson, F.R.S., the new president, was to deliver on the following day his address (in part) to the association. It refers to heredity and variation as factors in organic evolution, in the light of, and along the lines of, the discoveries made many years ago by Gregor Mendel of Brünn, and now embraced by the term Mendelism. After a stay of six days the visitors proceed to Sydney, and in that city, on August 20th, the concluding portion of the president's address will be given. Following another stay of six days, the association moves on to Brisbane, where the remainder of the official programme will be carried out, concluding on August 31st. In the course of the itinerary thus outlined a series of public lectures will be delivered (beginning at Adelaide on the subjects: "Saving and Spending," (Prof. Gonner); "Brown Earth and Bright Sunshine," (Prof. B. Moore, F.R.S.); "The Making of a Big Gun," (Dr. W. Rosenhain, F.R.S.); "Comets," (Prof. H. H. Turner, F.R.S.); "Clocks," (Sir Henry Cunynghame); and "The Decorative Art of Papua," (Dr. A. C. Haddon, F.R.S.).

During the tour, the presidents of sections will deliver the customary addresses relative to the respective branches of science which they represent. Prof. F. T. Trouton, F.R.S., of University College, London (mathematical and physical science section), is detained at home through illness, and his presidential address will be read by a colleague. Sir Ernest Rutherford, F.R.S., opens a discussion on the structure of atoms and molecules, and the Astronomer Royal reads a paper on the distribution in space of the stars near the north pole. Prof. W. J. Pope, F.R.S., of Cambridge University (chemistry section), expounds new researches in crystallography. Sir Thomas Holland, K.C.I.E., F.R.S., of Manchester University (geology section), following the delivery of his presidential address will open a discussion on the physiography of arid lands. Prof. Arthur Dendy, F.R.S., of King's College, London (zoology section), is to discourse on evolution; and there will be a discussion on mimicry in Australian insects. Sir Charles Lucas, K.C.B. (geography section), gives an address on man as a geographical agency. Many interesting papers are before the section, including one on Central Australia and its possibilities. Prof. E. C. K. Gonner, of Liverpool University (economic science and statistics section), will invite attention to three papers on town planning; and Sir Henry Cunynghame will discuss the effects of monopoly on prices. Prof. E. G. Coker, of Finsbury College (engineering section), will deal with stress distribution. Sir Everard im Thurn, K.C.M.G. (anthropology section), is to discourse on primitive peoples in Australasia; and there will be a paper by Prof. G. Elliot Smith, F.R.S., of Manchester University, on the origin and spread of certain customs and inventions. Prof. B. Moore, F.R.S., of Liverpool University (physiology section), takes the subject of the value of research in the development of national health. Prof. E. O. Bower, F.R.S., of Glasgow University (botany section), will discuss the Australian flora, its types, and adaptations. Miss E. R. Saunders contributes a paper on the double stock, detailing its history and behavior during cultivation. Prof. John Perry, F.R.S. (educational science section), discourses on the relations of university and state, and Prof. H. E. Armstrong, F.R.S., recapitulates before this section his views on science and education. Dr. A. D. Hall, F.R.S. (agriculture section), has chosen the subject of land reclamation and cultivation. There will be several contributions on wheat growing and wheat breeding in Australia.

In addition to the foregoing sectional proceedings, joint discussions have been arranged on wireless telegraphy, to be opened by Sir Oliver Lodge; and on the past and present relations of Antarctica in their biological, geographical, and geological aspects, to be introduced by Sir Douglas Mawson, the Antarctic explorer.

"Napier's Bones"*

By Prof. George N. Gibson

In popular estimation it is perhaps the phrase "Napier's Bones" that most readily recalls his name. Though the device is now of little practical importance,

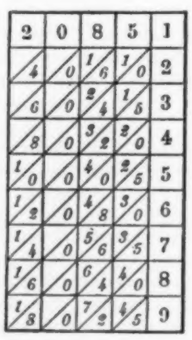


Fig. 1.

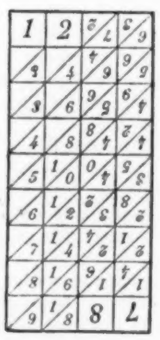


Fig. 2.

it is at least an instance of Napier's faculty of combining simple practical applications with great theoretical insight. The Bones are described, though not under that name in the book: "Rabdologiae, seu Numerationis per Virgulas Libri Duo: Cum Appendice de expeditissimo Multiplicationis Promptuario. Quibus accessit et Arithmeticae Localis Liber Unus." (Edinburgh: Andrew Hart, 1617.) The book is dedicated to Alexander Seton, Earl of Dunfermline, and in the dedication Napier states that he was induced to publish a description of the construction and use of the "numbering rods" (that is, of the "bones") because many of his friends to whom he had shown them were so pleased with them that the rods were already almost common and were even being carried to foreign countries.

Mr. Glaisher, in his article on Napier in the "Encyclopædia Britannica," gives a clear account of the numbering rods or bones, and as I cannot improve upon it I transcribe it here. The bones as described by Mr. Glaisher are slightly different from those that appear in the "Rabdologia" but represent a common type.

The principle of "Napier's Bones" may be easily explained by imagining ten rectangular slips of cardboard, each divided into nine squares. In the top squares of the slips the ten digits are written, and each slip contains in its nine squares the first nine multiples of the digit which appears in the top square. With the exception of the top square, every square is divided into parts by a diagonal, the units being written on one side and the tens on the other, so that when a multiple consists of two figures they are separated by the diagonal. Fig. 1 shows the slips corresponding to the numbers 2, 0, 8, 5, placed side by side in contact with one another, and next to them is placed another slip containing, in squares without diagonals, the first nine digits. The slips thus placed in contact give the multiples of the number 2085, the digits in each parallelogram being added together; for example, corresponding to the number 6 on the right hand slip we have 0, 8 + 3, 0 + 4, 2, 1; whence we find 0, 1, 5, 2, 1 as the digits, written backward, of 6×2085. The use of the slips for the purpose of multiplication is now evident; thus, to multiply 2,085 by 736 we take out in this manner the multiples corresponding to 6, 3, 7 and set down the digits as they are obtained, from right to left, shifting them back one place and adding up the columns as in ordinary multiplication, viz., the figures as written down are:

$$\begin{array}{r} 12510 \\ 6255 \\ 14595 \\ \hline 1534560 \end{array}$$

Napier's rods or bones consist of ten oblong pieces of wood or other material with square ends. Each of the four faces of each rod contains multiples of one of the nine digits, and is similar to one of the slips just described, the first rod containing the multiples of 0, 1, 9, 8, the second of 0, 2, 9, 7, the third of 0, 3, 9, 6, the fourth of 0, 4, 9, 5, the fifth of 1, 2, 8, 7, the sixth of 1, 3, 8, 6, the seventh of 1, 4, 8, 5, the eighth of 2, 3, 7, 6, the ninth of 2, 4, 7, 5, and the tenth of 3, 4, 6, 5. Each rod, therefore, contains on two of its faces multiples of digits which are complementary to those on the other two faces; and the multiples of a digit and its complement are reversed in position. The arrangements of the numbers on the rods will be evident from Fig. 2, which represents the four faces of the fifth bar. The set of ten rods is thus equivalent to four sets of slips as described above.

To the above extracts from Mr. Glaisher's article I may add that the bones had a great vogue, and were very extensively used for several years after Napier's death. The "Rabdologia" was translated into Italian and Dutch, and the Latin edition was republished at Leyden. In "The Art of Numbring By Speaking-Rods: Vulgarly termed 'Nepier's Bones,'" which was published at London, in 1667, William Leybourn (who is denoted on the title page simply as W. L.) gives a description of the rods, with examples of their use in multiplication, division, and the extraction of square and cube roots.

* Extract from a paper read before the Royal Philosophical Society of Glasgow.

A New Safety Device for Coal Mines is described in a report from the American consul at Dunfermline, Scotland, its purpose being to prevent the fall of the cage in case the rope of the latter breaks. Two extra chains come from the base of the rope, and these running down the sides of the cage are fastened to four pieces of strong wood that project from the four bottom corners of the cage. While the weight of the cage rests upon these pieces of wood the latter are drawn inside the cage, but when relieved of this weight, by the breaking of the rope, they are spread outward by springs and catch the buntings with which the sides of the shaft are laced, and the cage is brought to a standstill within a maximum space of four feet.

The Total Solar Eclipse, of August 21st

By William J. S. Lockyer

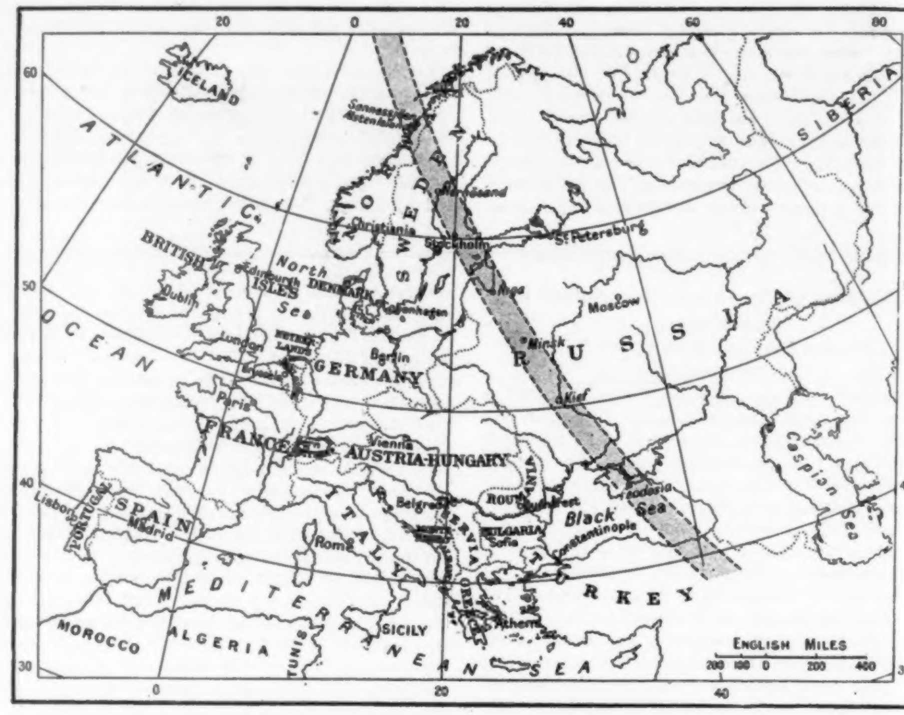


Fig. 2.—Map showing path of the shadow track.

OWING to the great strides made in the study of the physics of the sun, the importance of the occurrence of a total eclipse of the sun is not so great as it was toward the latter end of last century. Nevertheless, there are still some problems to be solved, the data for which can only be obtained on these occasions, thus necessitating the organization and dispatching of observers to several stations lying on the path traced out by the cone of the moon's shadow as it sweeps over the earth's surface.

The present year presented us with a total eclipse as near at home as that which occurred in the year 1896; in fact, these eclipses belong to the same family, and it is likely that the event was as well attended by both amateur and professional astronomers as was its forerunner. It is hoped, however, that weather conditions were more favorable for successful observation, for it will be remembered that on the last occasion the only party that was fortunate enough to come home with results was that which took up a station in Nova Zembla.

European observers were especially favored by the position of the path of the moon's shadow, because the greater portion of the accessible track cuts Europe diagonally through its central portion. Thus, with comparatively little journeying, very favorable stations for observation were reached.

The accompanying illustration (Fig. 1) shows the general position of the line of central eclipse. It will be seen that the eclipse began at a point situated in north latitude about 71½ degrees and ended in a latitude a little greater than 23½ degrees. The moon's shadow first struck the earth in far north Canada, passing a little south of the Parry Islands, and pursuing its course just above Baffin's Bay. There it entered Greenland, and swept across this sparsely inhabited region, emerging into the Arctic Ocean. Taking a southeasterly trend, it entered Norway near the island of Vega, and passed out of Sweden near Hernösand, and then crossed the Gulf of Bothnia and the Baltic Sea. The track then entered Russia at Riga, and passed near Minsk, Kief, and the eastern part of the Crimea, crossing the Black Sea and reaching the opposite coast at Trebizond. It then traversed eastern Turkey and western Persia, and terminated its course on the northwest coast of India.

There is little doubt that the first portion of the eclipse track—that is, the part that crossed the islands north of Canada and Greenland—was not occupied by special observers. From Norway southeastward the case will be different, for there the sun was at a useful altitude and the eclipse of long duration. On the west coast of Norway the sun had an altitude of a little over 35 degrees, and the duration about 126 seconds. On the east coast of Sweden the altitude was more than 36.5 degrees, and the duration 128 seconds. In the region about the Gulf of Riga the sun's altitude was about 39.5 degrees, and the duration 133 seconds. By the time the Crimea is reached the altitude was somewhat reduced, namely, 36 degrees 40 minutes, and the duration diminished to 129 seconds. An excellent large-scale chart of the whole track of the eclipse across Europe accompanies Count de la Baume Pluvinel's article which appeared in the March number of the *Bulletin de la Société Astronomique de France*, and this was valuable to those who wished to take up a suitable position on the track. Those who proceeded to Norwegian stations found useful data published recently in the *Observatory* by Prof. H. Geelmuyden. There it is stated that among stopping places for the ordinary coast steamers, going out from Bergen or Trondhjem, may be named Sannessjöen, situated on the north end of the Alsten Island, from which stations near the central line will be easily accessible, either on the same island or (by motorboat or local steamers) on some other islands toward the northwest. From Mosjöen, situated at the end of the deep Vessen Fjord, stations near the central line in the Vessen Valley may be reached by carriage. Brönnö is a stopping place not far from the southern limit, and Bodö is a little outside the northern limit. Details concerning the path of the shadow track across Turkey and Persia and the accessible places for forming camps in these countries were described in these columns (No. 1998, April 18th), so that further reference to these regions becomes unnecessary.

* Reprinted from *Nature*.

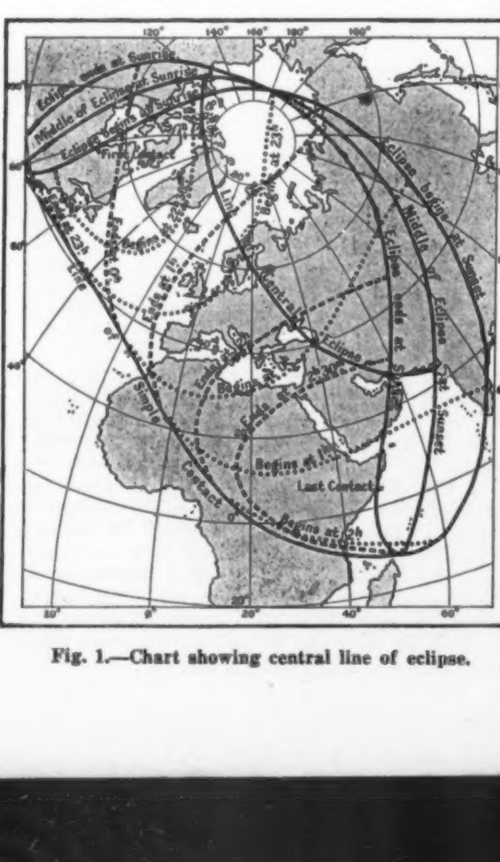


Fig. 1.—Chart showing central line of eclipse.

With regard to the weather conditions the probability of fine weather seems to increase the farther east along the track the station is taken up. According to the information that is to hand, most of the main official expeditions were to be located along the Russian portion of the line, where the good weather chances are more promising, but this did not deter others from occupying Norwegian or Swedish stations, for the more scattered the observers are the more chance there is of some results being secured.

As to the actual expeditions that were projected, the following statements may be made, and the accompanying map (Fig. 2) will help to indicate the positions of the stations which were proposed. Dealing first with the British parties, the joint permanent eclipse committee of the Royal and Royal Astronomical Societies was to send out five observers. Three of these observers, namely, Prof. Fowler, Mr. W. E. Curtis, and Major Hills, were to be stationed near Kief in Russia, and undertake the photography of the spectrum of the chromosphere during the partial phases, and a grating giving much higher resolving power than any previously employed during an eclipse was to be used. Fathers Cortie and O'Connor were being sent to Hernösand in Sweden to undertake direct photographs of the corona and photographs of the spectrum of the corona with special regard to the yellow and red regions. They were to be accompanied by Messrs. J. J. Atkinson and G. J. Gibbs as volunteer helpers.

From the Royal Observatory, Greenwich, two observers, Messrs. Jones and Davidson, took up their station at Minsk, in Russia. The programme of this party consisted in securing large-scale photographs of the corona, the spectrum of the corona and chromosphere, more especially in the ultra-violet region, and photographs of the corona through "mercury-green" glass for investigation of the distribution of "coronium." Near Feodosia, in the Crimea, the party from the Solar Physics Observatory, at Cambridge, namely, Prof. Newall, Mr. Stratton, and Mr. C. P. Butler, were located. The work undertaken included small- and large-scale direct photographs of the corona for extensions and details, respectively, objective grating photographs of the chromosphere for comparison with the slit spectra taken by Prof. Fowler's party, and lastly, polariscopic observations.

Feodosia was to be the observing station of two German expeditions, namely, one from the Astrophysical Observatory at Potsdam, and a second from the Royal Observatory in Neubabelsberg, near Berlin. Near Feodosia, at Starg Krym, an expedition from the Hamburg Observatory in Bergedorf was to take up its position. The programme of the work to be undertaken by this expedition, kindly communicated by the director, Prof. R. Schorr, included photographs of the corona with telescopes of focal lengths of 4, 10, 20, and 40 meters, with and without screens, a search for intermercurial planets, and photographs of the spectra of the chromosphere and corona.

In addition to the above, Prof. Miethe, of the photochemical laboratory of the Technical High School in Berlin, proposed going to Sannessjöen, Alsten Island, in Norway, and it is quite possible that parties from other German observatories added to the number of expeditions.

Feodosia was also the selected spot for three French missions, details about which have been kindly communicated by Count de la Baume Pluvinel. Count de la Baume Pluvinel himself was to lead a private expedition, with Messrs. Senouque and Rougier as his assistants. Their instrumental equipment consisting of a two-mirror coelostat worked in conjunction with objectives of 12 and 3 meters for the photography of the corona. Two slit spectroscopes and two prismatic cameras with flint and quartz prisms were also to be used, and measures were to be made of the intrinsic brightness of different portions of the corona.

A second expedition was to set out from the Nice Observatory under the direction of M. H. Chrétien. M. Chrétien was to be accompanied by M. Lagrula, and they expected to take up a position at Feodosia. Their main instrument was to be a coelostat with two mirrors, one of which was to feed an objective of 6 meters focal length, for securing photographs of the partial phases and of the corona; the other to supply light to a slit spectroscope for the study of the rotation of the corona. M. Chrétien proposed also to make photometric measures during the partial phases. M. Jekhowsky ex-

pected to join this party, and use a concave grating of 6 inches diameter and 7 meters radius of curvature for the study of the spectrum of the chromosphere in the ultra-violet.

M. Salet, of the Paris Observatory, was to go privately to Feodosia, taking both an equatorial and a coelostat, and his chief endeavor was to be the photographic study of the polarization of the light of the corona.

Feodosia was also the station that Dr. Perrine expected to observe from; and of the expedition being organized by the Lick Observatory under Prof. W. W. Campbell, one section was to proceed to Kief, while the other occupied Feodosia. A Russian party under Dr. Donitch also took up quarters at the latter place.

While most of the expeditions were concentrating at Feodosia, it is hoped that other intending observers took up positions farther north. No doubt several amateurs, both British and foreign, also completed their plans for the event.

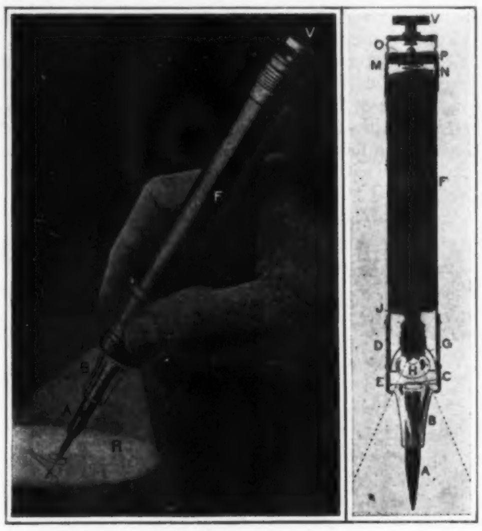
It is interesting to note that while a total solar eclipse does not offer very much scope for the use of color photography, yet several attempts were to be made with small instruments. Writing from the Nikolai chief observatory at Pulkovo, Prof. Backlund (*Astr. Nach.*, No. 4740) states that after a conference with the Minister of Finance, every facility would be offered by the Government to further the interests of the various expeditions proceeding to Russia, and that all instruments would be customs free provided observers return with them.

A Pencil for Writing in the Dark

Our illustration, which is derived from *La Locomotion*, shows a rather ingenious little device, a pencil for writing in the dark. The half-tone engraving shows the general appearance of the pencil in use, while the line cut on the right displays some of the details of the inner mechanism. The source of electricity is a small cylindrical dry cell with one pole insulated. The other pole, as is customary in such cases, is formed by the metallic container of the cell itself, which, to prevent any possible short-circuiting, is inclosed in a paper sheath. The body of the pencil is formed of a nickel-plated tube, closed at each end by a plug. The lower portion of this serves as a support for the pencil head, which holds the lead. Our illustration shows this head screwed to a small glass cone, which itself is held in place by a ring. Within the lower plug and screwed upon the main tube in an enlargement formed in a reflector, a small electric lamp is placed. This is of the usual Edison type, with screw socket.

The upper plug is also quite simple. It contains a disk of insulated fiber, pierced by a stud serving as a support for a coil spring. Above this is a screw provided with a milled head, which, upon screwing down, causes the stud and spring to communicate with the body of the apparatus.

After unscrewing the upper plug a small cell can be introduced, with its insulated pole following. This pole, in operation, is in contact with the corresponding pole of the lamp. The upper plug is now screwed into place, the milled head being unscrewed to its limit. The



A, point; B, glass cone; C, adjusting screw; E, cap; F, body; G, reflector; H, lamp; K, dry-cell; L, contact; N, spring; O, contact plug; V, set screw.

spring presses upon the container of the cell, holding it in place, but being insulated it cannot close the circuit. If now the milled head is screwed in, a circuit is established through the following points: first pole of the lamp, first pole of the cell, second pole of the cell, spring, screw, second pole of the lamp. Thus the circuit is completed and the current passes through the lamp and lights it up. The lower plug supporting the pencil head can very easily be drawn in, and the little pencil can also be converted very readily into a pocket torch, by substituting another lamp and cell, which can be done in a few seconds.

This little instrument should prove something more than an interesting toy; it seems to be destined to fulfill a definite and useful function.

New Synthetic Coal Gas

A new lighting gas has been prepared which is claimed to be much less toxic than water-gas or air gas, and yet possessing a calorific power approximating to that of coal gas, and, therefore, far greater than that of water gas or air gas. The new gas may be obtained from coal, from coke, or from water gas. When coal is used, this is first mixed with lime, and distilled at 900 to 950 deg. Cent. A current of steam is then introduced over the coke so produced, maintained at 900 to 1,000 deg. Cent. The total yield of gas, freed from carbon dioxide, is about 200 cubic meters of gas from 100 kilos of coal. In contains 70 to 78 per cent of hydrogen, 15 to 20 per cent of methane, and 5 to 10 per cent of carbon monoxide. By regulating the reaction, the amount of carbon monoxide may be reduced to practically nil. The amount of ammonia recovered as a by-product is more than four times that obtained from the same coal by the ordinary methods of distillation, and the volume of lighting gas is eight to ten times greater. The whole of the nitrogen present in the coal is converted into ammonia.—*Comptes rend.*

Driving Away Mosquitoes

Closed wells and cisterns are favorite places for mosquitoes to deposit their eggs, and for the purpose of driving them away the use of naphthalin has been suggested. Naphthalin, however, imparts an unpleasant taste and odor to drinking water, so instead of sprinkling it on the surface of the water, after the manner of using oil for the purpose of ridding the water of mosquito and gnat larvæ, a good plan is to suspend a bag containing naphthalin over the water. The readily volatilized substance will charge the air in any confined space and drive away the female mosquito that selects this place for her eggs. Th same method might be effectively adopted for the protection of dark and damp places about houses. Experiments have shown that naphthalin vapor resulting from natural evaporation is fatal to larvæ in water as well as to the adult *Culex pipiens*.

A Substitute for Platinum

So great is the demand for platinum, for use in electrical apparatus, that many efforts have been made to devise some substitute that can take its place and be produced at a moderate price. A recently patented substitute that is claimed to be suitable and satisfactory for electrical contacts consists of an alloy of 45 per cent platinum, 15 per cent gold, 25 per cent silver, and 15 per cent copper.

Much of the Cork Used Throughout the World comes from Portugal, which harvests about 50,000 tons a year.

The Flying Machine from an Engineering Standpoint—III*

A Review of Recent Progress

By Frederick William Lanchester, M. Inst., C.E.

Continued from Scientific American Supplement No. 2015, Page 112, August 15, 1914

4. *Body Resistance.*—The body resistance, as already stated, varies approximately as the square of the velocity. It is therefore evident that, with a machine of given weight, since the flight resistance proper (the aerofoil resistance) is constant, the higher the flight-speed the more serious relatively does the question of body resistance become, and the design of the car and its accessories, such as alighting gear, etc., is a matter of increasing importance as the contemplated flight velocity becomes greater. The calculation of body resistance involves the computation of the resistance of each individual element, and in some cases allowances for the interference or influence of one element or portion on another. Thus in the computation of body resistance it is necessary to have at command tabulated results of the resistance of spars of various sections, wires, wheels, and the like, in addition to a sufficiency of known data as to stream-line forms of various degrees of perfection. A considerable amount of experimental data has now been collected in this direction, but a great deal yet remains to be done.[13]

The resistance of the body-shape or fuselage is a factor on which at present the information available is the least satisfactory, since it is rarely possible for the designer to adopt a close approximation to a perfect stream-line form, or a form for which the resistance coefficient has been already determined; it is usually necessary to have recourse to model experiment in each individual case. This is no more than must be expected, in view of the fact that the same applies to the design of a ship's hull when any departure is made from existing practice.

A very few years ago little or nothing was known as to the resistance of the so-called stream-line or ichthyoid body. In 1908-9 I made inquiries in the endeavor to

Table VIII.

Authority.	Date.	——	Remarks.
Prandtl..........	1908	0.125	Given as approximate only.
Colliex..........	1908	0.100	From rough experiments at the factory of Voison Freres.
Surcouf..........	1908	0.031	Given as an experimental determination by the late Colonel Renard.
British Admiralty..	1909	0.032	Actual for water (ratio about 3 : 1).
		0.023	Probable for air.

obtain some figures on this subject. For bodies constituting a rough imitation of a good fish form, with ratio of length to diameter of about 6 to 1, the figures given in Table VIII were supplied by the different authorities named; the figures, given to me in various forms, are here reduced to represent the equivalent of normal plane in terms of the maximum cross-section.

It would appear from more recent experiments, carried out at the Royal Aircraft Factory, and at the National Physical Laboratory, that for a well-designed stream-line form the best result so far recorded is approximately 0.07, the coefficient of fineness—length/diameter—being round about the value 4 : 1.

The plotting given in Fig. 20 is based on a series of determinations made at the Royal Aircraft Factory, with corrections (for which I take responsibility) to compensate for the difference in the coefficient of skin-friction between the velocity, 20 foot-seconds, actually employed and an assumed flight-speed of 70 miles an hour. The plotting represents the resistance coefficient for bodies of about 2 feet to 3 feet diameter.

When we turn our attention to the design of the body of machines as they exist to-day, we find that although it is becoming customary to give the fuselage a distinct fish-like outline, it is rare that any real attempt is made to adopt a definitely stream-line or true ichthyoid form, such as employed for the experimental determinations already cited, and commonly used for dirigible balloons. It is not sufficient to give a rough general outline to the body if a material reduction in the resistance is required; it is necessary to go further than this, and to avoid, as far as possible, corners and projections of every description. In many cases in the body-forms used to-day the resistance is nearly as great as that of a normal plane equal to the mid-section area, and a body with a coefficient of less than 0.5, in view of current practice, must be regarded as exceptionally

* The James Forrest lecture, delivered before the Institute of Civil Engineers on May 5th. Compare also the same author's paper on "Catastrophic Instability in Aeroplanes," Scientific American Supplement, February 14th, 1914, page 98.

[13] For the resistance co-efficients of spars, wires, etc., reference should be made to the various reports of the Advisory Committee for Aeronautics and the work of Mr. Eiffel and others, also section 9 following.

good. As a consequence the resistance of the fuselage and passengers alone is often equivalent to some 3 or 4 square feet, whereas an equivalent considerably less than 1 square foot ought to suffice. It is not only necessary to avoid up-standing projections, such as wind-screens, etc., but even such things as longitudinal angles should be eliminated from the design; this latter point has been partially investigated by the National Physical Laboratory.

In the Paulhan-Tatin machine, mentioned in the researches of Mr. Eiffel, the question of body form has been studied with extreme care, the form of body employed being substantially a solid of revolution, as given in Fig. 21*a*. The only irregularity in the fuselage is in the aperture for the pilot's body, which has clearly been reduced to the minimum possible. According to the results given in Fig. 20 it would be still better, from the point of view of resistance, to design the body on the lines shown in Fig. 21*b*, making the body only of sufficient length to contain the pilot, motor, etc., and carrying the tail-organs from a tubular continuation. A model of this kind, made and tested at the National Physical Society (from designs of the Royal Aircraft Factory), gave a normal plane equivalent of about one fifth of its maximum cross-section. The form was imperfect as a stream-line body, and the small scale (1/25 full size), otherwise rendered the resistance higher than would be in actuality.—Advisory Committee, Report 74, page 177.

It is evident that with sufficient experience the body fuselage resistance of an ordinary two-seat machine should be capable of reduction to the equivalent of 1 square foot area of normal plane, since a good model of stream-line body of 5 square feet maximum section should in itself offer less than half this resistance. Added to this, we have the alighting chassis and auxiliary surfaces, the resistance of which should be capable of being designed for an equivalent of 2 square feet if the design be studied in every detail, making 3 square feet in all. On a basis of 80 miles an hour, the resistance will then amount to 60 pounds, or, say, approximately, 5 per cent. The body resistance in the machines of to-day is very much higher; it is commonly the equivalent of at least some 5 square feet of normal plane. Mr. Eiffel gives 1 square meter (10 square feet) as usual.

5. *Total Resistance.*—Fig. 22 represents graphically the position with which the designer has to cope; the horizontal line *a a* represents an aerofoil resistance coefficient of 7 per cent. The curve 2 represents (from *a a* as datum) the additional coefficient due to body resistance on the assumption that we are dealing with a machine of 1,200 pounds weight, in which the body resistance has the equivalent of 2 square feet area of normal plane curve, 3 represents similarly the added body resistance on a basis of 3 square feet; lines 4 and 5, 7 and 10, represent 4, 5, 7, and 10 square feet, respectively; curve 5 may be taken roughly to represent the best practice at the present time. It is evident that so long as flight-speeds were limited to 40 miles an hour or less, as was the case a few years ago, the body resistance remained a matter of minor importance; in fact, in the Wright machine, and in several other machines of that day, the pilot sat fully exposed, and little or no attempt was made to minimize resistance, whereas with speeds of 80 miles an hour the body resistance will, unless great care is taken in the design, considerably exceed the flight resistance proper. Fig. 22 does not represent the resistance of a given machine, flown at different speeds, but rather the resistance of a series of machines of given weight, each designed for least resistance at its own particular speed, and with body resistance equivalent to the area indicated.

Referring to Fig. 22, it will be seen that the total traction coefficient in the case of curve 5 at 80 miles an hour is, roughly, 15 per cent, the gliding angle consequently being 1 in 6.7; this is slightly better than the best figures actually obtained in the military trials of 1912. The highest speed at the military trials did not touch 70 miles an hour, so that on the basis given the gliding angle should have been better than stated; no allowance was made for the drag of the propeller, and it is possible the difference is due to this factor.

The question of body resistance has for some time been a matter of careful study by the staff of the Royal Aircraft Factory, and I understand that in some of the later models the equivalent normal plane area has been very considerably reduced. If we take an aerofoil coefficient of 7 per cent, and a curve representing 3 square feet equivalent normal plane, we find that at 80 miles an hour the gliding angle, or the resistance coefficient, should be approximately 12 per cent, or at 60 miles per hour 10 per cent. I believe this figure to be in sight, though it may not yet have been actually reached.

As illustrating the extent to which the present-day results have been anticipated by theory, in 1907, dealing with the question of the power expended in flight, I tabulated the results of calculations for gliding angles as for complete machines ranging from 12 degrees (approximately 1 in 5) to 6 degrees (approximately 1 in 10). In the military trials of 1912 the worst gliding angle recorded was 1 in 5.3, and (as pointed out in the preceding paragraph) the present-day figure is gradually approaching 1 in 10.

If we try in the light of present data to look into the future, it seems probable that the limiting gliding angle, or, rather, the minimum total coefficient of resistance may even be materially less than 1 in 10; thus, if it is found possible, in spite of structural difficulties, to obtain equal results in an actual machine to those obtained in wind-channel model tests—namely, a coefficient of resistance for the aerofoil approximately to 5 per cent—and if the body area equivalent, for a machine of, say, 1,200 pounds gross weight, can eventually be reduced to 2 square feet, a total coefficient of resistance as low as 8 per cent may prove well within reach; whether the sacrifices necessary in order to achieve such results in practice would be justified, the future alone can decide. The solution of any engineering problem is always to some degree a matter of compromise, and it would be rash to suggest that in the case of the flying machine there are not considerations of sufficient importance to render it inadvisable to run after the last 1 per cent reduction in tractive effort. A graph is given representing the coefficient of resistance on the basis of the present paragraph in Fig. 22. The aerofoil coefficient of traction is taken at 5 per cent, the weight of the machine, as before, assumed as 1,200 pounds, and the suggested total of 8 per cent corresponds to a flight speed of nearly 80 miles an hour.

Before we have finished with the question of resistance, we need to know something as to the gradient of ascent, or climbing power required. A machine that

Fig. 20

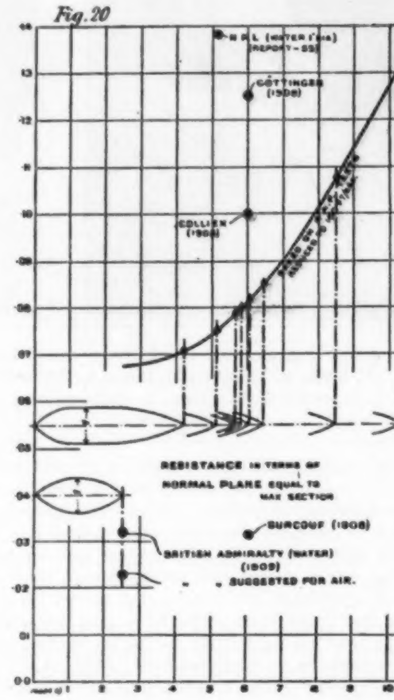


Fig. 21.

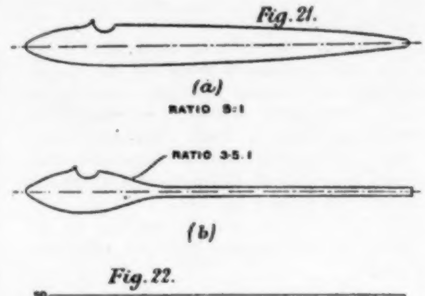


Fig. 22.

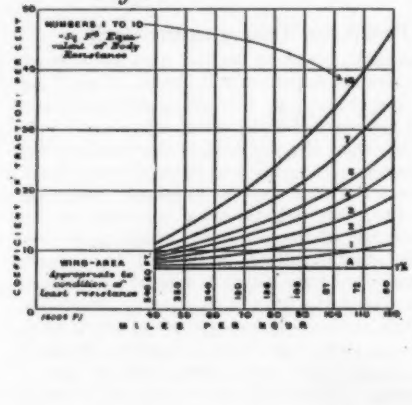


Fig. 24.

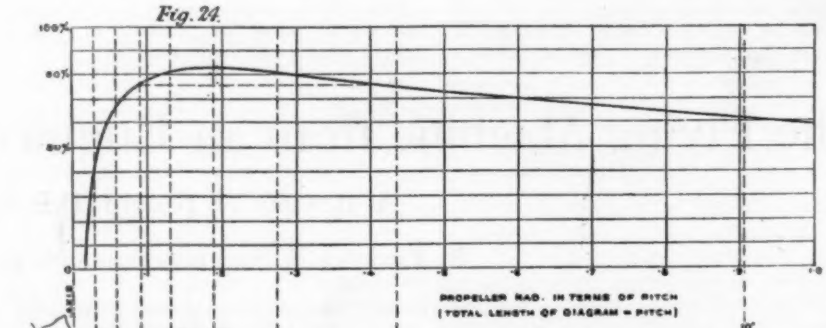


Fig. 23.

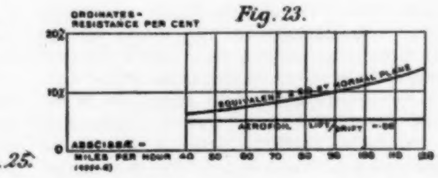
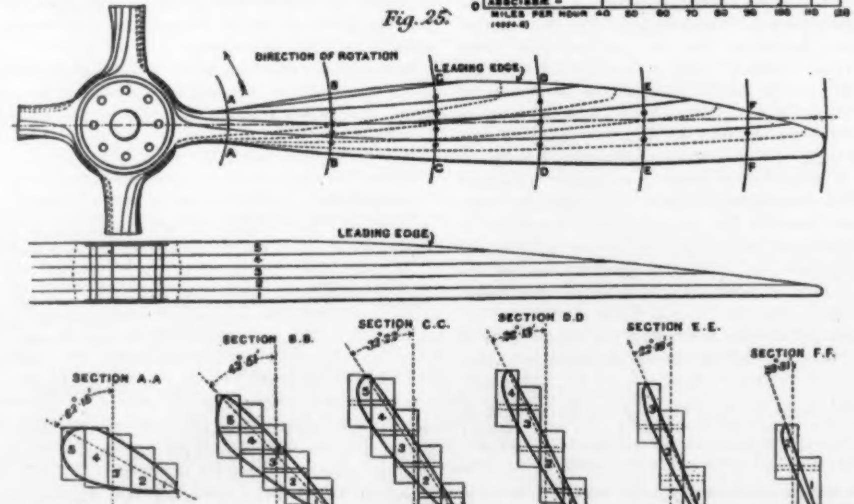


Fig. 25.



is only capable of horizontal flight is evidently quite unserviceable; it is well understood, too, that any machine with an insufficient rate of ascent is intrinsically dangerous; not only does it remain too long at low altitude, where any "fluke" in the wind is to bring about disaster, but in bad weather, when buffeted about by the wind, a pilot may find himself incapable of making altitude altogether if his initial margin of power is insufficient.

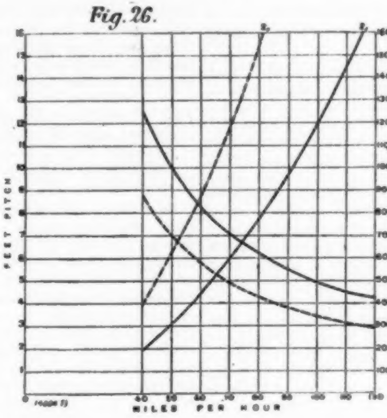
The rate of ascent for which provision has to be made depends very much upon the service for which the machine is required; for the ordinary needs of the aeronaut who wishes to make cross-country flights under fair-weather conditions, a margin of power representing an up-grade of 5 per cent or 6 per cent appears to be ample; there is probably no real advantage in any greater provision. For military or naval service, on the other hand, there are without doubt occasions when everything may depend upon the rapidity at which the machine can make altitude. I feel that I cannot do better than quote from the specifications given by the superintendent of the Royal Aircraft Factory for two types of machine, namely, "R.E. 1" reconnaissance aeroplane, and "F.E. 3" gun-carrying aeroplane.[19] For the first of these the rate of climbing demanded is 600 feet per minute, or, taking the normal flight-speed at 70 miles per hour (the specification gives maximum 78 miles per hour, and minimum 48), we have a climbing gradient of approximately 10 per cent. For the gun-carrying machine the speed is given as 75 miles per hour, and the rate of climbing 350 feet per minute, which, expressed as climbing gradient, is a trifle less than 5½ per cent. Manifestly a machine carrying a gun of some kind (presumably a machine-gun), and we may assume an adequate supply of ammunition, and perhaps a few square feet of bullet-proof armor-plate, needs to sacrifice something in the matter of climbing power.

There is good reason to suppose that if a demand for higher speeds than those at present attained is in the future to be satisfied, success will depend to some extent upon our ability to build larger and heavier machines. By reference to Figs. 22 and 23 it will be seen how soon with increased flight-speeds the question of body resistance becomes a disproportionate factor; it is manifestly impossible in a machine of given size to reduce the equivalent normal plane area beyond a certain point, but it is evident that by increasing the weight and power of the machine the effect of such body resistances may be rendered less important, since an increase in weight and power does not require a proportionately serious increase in the size of the members to which the body resistance is due. Also since the square of the product of l and V varies directly as the weight (where l represents the linear size of the aerofoil) the value of ξ is also a function of the weight, and diminishes slightly as the weight is increased.[20]

6. *Propulsion.*—We are now in a position to consider the question of propulsion. Whether we appeal to experience or theory it would appear that there is only one method of propulsion available, namely, the screw-propeller.[21] The problem of propulsion, whether aeronautical or submarine, is essentially the same; the laws of dynamic similarity, with certain reservations, are strictly applicable. Roughly speaking, the conditions of usage of propellers in water and air may be compared by merely taking cognizance of the relative densities of the two media—approximately 800 to 1. The laws of dynamic similarity indicate that this relation is not exact, but any refinement of theory on this score is of academic rather than of practical importance. Apart from fine points of this kind, there is a limitation that renders the air propeller and the marine propeller not strictly comparable; this limitation is due to the appearance of the phenomenon known to the naval engineer as cavitation. The law of the relation of pressure to velocity for least resistance applies to the blade of the screw-propeller precisely as it does to the aerofoil itself, so that if a propeller is being designed for least resistance the pressure per square foot at any point of the blade must bear its constant relation to the square of the velocity of the blade through the fluid at that point. In the case of the marine propeller this results in a speed being reached (at about 20 or 25 knots speed of vessel) at which the velocity of the blade-tips is such that the negative pressure (on the back of the blade), based on the law of least resistance, is greater than the hydrostatic (absolute) pressure. Under these conditions a vacuum is formed in the vicinity of the blade extremity, and the system of flow is impaired; this is the condition of incipient cavitation, and as the speed is progressively increased the vacuum invades more and more of the blade area, until the greater part of the propeller becomes ineffective. From the critical speed upward the design of the marine propeller becomes a compromise. The extremity of the blade is first designed broader to avoid developing pressures sufficient to initiate cavitation, and then, owing to the additional skin friction thereby involved, it is found desirable to adopt higher pitch/diameter ratio to prevent the extremities cutting the water with excessive velocity. Eventually the propeller for high-speed craft becomes one of extremely coarse pitch, with blades of short or saucer-like form. No such thing as cavitation is experienced in the aeronautical propeller; if we should require to deal with propeller-blade speeds approaching the velocity of sound, we might find something analogous, due to the high rarefaction of air, but at present the aeronautical designer can afford to ignore all question of cavitation.

It is frequently stated that the theory of the screw-propeller is entirely empirical and quite unsatisfactory; this is not my opinion. The theory of the screw-propeller, based on the theory of the aerofoil as laid down in my "Aerodynamics,"[22] appears fully to meet the requirements of the aeronautical designer. According to this theory the propeller-blade is treated as an aerofoil,

Fig. 26.



its P/V^2 ratio at every point of the blade is fixed by the same law as that of the aerofoil as given; following this the gliding angle of the propeller-blade is constant from root to tip. The section of the blade is at every point designed as an aerofoil, in which the true helical surface corresponds to the horizontal plane in flight.[23] Under these circumstances it is shown in my work that each point of the propeller-blade has efficiency proper to itself, and is represented by a curve as plotted in Fig. 24, which corresponds to a gliding angle of 6 degrees, or, approximately, 10 per cent. Under these conditions it will be seen that the region of maximum efficiency is just over 81 per cent. Unfortunately, we cannot use only the region of maximum efficiency; we have to employ the blade of considerable length, and consequently parts of the blade have an efficiency below the maximum. If we take a propeller of the usual proportions, in which the pitch is about 1¼ times the diameter, that is, such a blade as is represented in Fig. 24, we see that the marine engineer declines to employ any portion of the blade with an efficiency of less than about 92 per cent of the maximum—that is to say, the efficiency of different points of the blade varies from 77.5 to 81 per cent, or, theoretically, the limit of efficiency of such a propeller should be round about 77 per cent. Unfortunately, a propeller "in being" cannot consist of blades alone, it requires a boss and a connection between the boss and the blades, and in driving these functionally useless parts through the water a considerable further loss is inevitable. Probably it is for this reason that the actual efficiency of a marine propeller rarely exceeds 70 per cent. In my work, a design is given of an aerial propeller based on theory alone, in which a very conservative estimate is taken of the gliding angle. If, in the light of present knowledge, we assume the propeller-blades being of the aspect-ratio corresponding to that of my 1894 gliding model, the gliding angle or resistance coefficient will be about 5 or 6 per cent, and we might anticipate a theoretical limit to the propeller efficiency of 88 or 90 per cent. We have here, as in the marine propeller, to provide a boss and arms, and we require to take into account the fact that it never pays in practice to take the full diameter of the propeller that theory would indicate (it is better to sacrifice a few per cent efficiency to save weight and clearance diameter). Everything considered, I am disposed to put a limit of efficiency of an aeronautical propeller at about 85 per cent: this is higher than has been found possible in marine engineering.[24]

My method of propeller design has been adopted and employed for some years by the superintendent and staff of the Royal Aircraft Factory with very satisfactory results; at present there is but little available information on the question of efficiency owing to the fact that the arrangements at the disposal of the Royal Aircraft Factory do not permit of the testing of full-sized propellers.

Working drawings of a propeller, designed at the Royal Aircraft Factory by this method, are given in Figs. 25 and 26. For the full exposition of the system of "lay out," reference should be made to the work already referred to.

As an alternative and purely empirical basis of treatment, we may fall back on our experience in marine propulsion. There is a practical rule which appears to be commonly adhered to in the design of successful marine propeller for moderate speed sea-going craft. The area of the propeller disk is approximately 1 per cent of the total wetted surface. This rule has been found by me to represent a rough average of the practice in various cases,[25] but whether it is an accepted rule or not I do not know. Let us take the case of a flying machine involving, say, a thrust of 200 pounds at 80 feet per second; at this speed the frictional air resistance will be approximately 0.035 pound per square foot of surface (0.07 pound per square foot of lamina—i. e., double surface); thus the resistance of the machine is approximately represented by 6,000 square feet "wetted" surface, and, following the rule given in the case of water, the propeller-disk should be 60 square feet; this corresponds to a propeller diameter of about 9 feet. In an actual machine of about this size the propeller is commonly of about 7 feet to 8 feet diameter, which, taking everything into account, is in substantial agreement. The propeller employed in flight is of necessity (from consideration of the engine revolution speed) of finer pitch than that of best efficiency. Under these conditions theory shows that the correct diameter is less than that of the propeller of best diameter pitch ratio, such as employed by the naval architect.

There are (in the present state of the art) two prominent reasons for the adoption of a propeller for aeronautical machines of finer pitch than that of greatest efficiency; first there is the question of suiting the pitch of the propeller to the running speed of the engine. For the power necessary in a modern aeroplane (from 50 to 100 horse-power) a stroke of about 5 inches is found to design well in proportioning the engine; now it is uneconomical both from the point of view of weight-saving and of gasoline consumption to employ too low a piston speed; in fact, for any given dimensions of cylinder the power developed is within limits roughly proportional to the piston speed. Taking a piston speed of 1,000 feet per minute and 5-inch stroke, we require 1,200 revolutions per minute = 20 revolutions per second. Assuming a velocity of flight of about 80 feet per second, the effective pitch of the screw requires to be 4 feet, or approximately equal to half the diameter of the screw, instead of at least equal to the diameter, as in a good marine propeller.

It is, of course, not difficult to gear down from the engine to the propeller, in fact, this has been frequently done, but, since gearing involves a tax of approximately 5 per cent of the horse-power, it is evidently better to drive direct and sacrifice something in the efficiency of the propeller, more especially as this course involves a far lower torque on the propeller-shaft, and consequently a lower recoil torque on the framework of the machine.

(*To be continued.*)

[19] Advisory Committee for Aeronautics, Report 1912–1913, page 267.

[20] Compare Appendix I.

[21] Nature's method of propulsion—wing-flapping—besides being very objectionable from a mechanical point of view, shows certainly no higher degree of mechanical efficiency than the screw-propeller.

[22] "Aerial Flight," vol. i., ch. ix.

[23] There is one factor which affects the analogy between the aerofoil and the propeller-blade; the latter is not able, to the same extent, to hold or accumulate a dead-water wake; the propeller-blade sheds its dead water continuously by centrifugal force. The extent to which this affects the problem has yet to be determined.

[24] There should be nothing to prevent the marine propeller (at speeds below the cavitation point) giving as high an efficiency as the aeronautical propeller, were it not for the limit imposed by the strength of materials. To obtain the highest efficiency even in an air-propeller it may be found necessary to abandon the wooden blade and substitute a solid nickel-steel blade of somewhat the sectional form given in Fig. 16, *ante;* this, in the case of an 8-foot propeller, would mean a blade 4 feet long, the outer 3 feet of which would be the effective blade, the maximum width in the widest part being no more than 3 inches or 4 inches. If any attempt were made to design such a propeller for marine work, there is no material known at the present time that would stand the stress involved; the pressure-reaction, speed for speed, would be about 800 times greater in water than air, and the aspect ratio of the blade that can be utilized for marine work is strictly limited by this fact; even the softest of timber is relatively far stronger as a medium for the construction of an aeronautical propeller than any known material, even tempered tool steel, would be for marine work. In the design of an aeronautical propeller, advantage may be taken of the fact that a very slight forward slope of the blades relieves the blades of all bending stresses, the resultant of the centrifugal force and pressure reaction is in the line of the blade, and the latter is consequently stressed in pure tension.

[25] The average of a number of war vessels, capable of about 18 to 20 knots speed, gave the figure 1.3 per cent. Two typical low-speed merchantmen (from particulars supplied by the builder) gave exactly 1 per cent.

NEW BOOKS, ETC.

FILTERS AND FILTER PRESSES FOR THE SEPARATION OF LIQUIDS AND SOLIDS. From the German of F. A. Bühler. London: Norman Rodger, 1914. 8vo.; 184 pp. Price, $4.80.

The subject of filters is a most important one in chemical technology, for the separation of solids from liquids is a frequent and regularly recurring problem in chemical factory practice. To describe and represent pictorially those forms of apparatus that up to the present have proved themselves the most useful is the object of this treatise. The improvements in filter presses are many and it is wise for chemical engineers to keep pace with the times. All the standard and many of the unusual filters and filter presses are described. The book is illustrated by 327 engravings, and there is an appendix dealing with the patents granted in the United Kingdom for filters, filter presses, etc.

ENGINEERING GEOLOGY. By Heinrich Ries and Thomas L. Watson. New York: John Wiley & Sons, Inc., 1914. 8vo.; 672 pp. Price, $4.

For some years the authors of this book have been giving to students of civil engineering in their respective universities a special course in geology as applied to engineering. The method followed by them has met with much success, and since the plan adopted has generally been put into operation in other universities, it has encouraged them to believe that it might be of service to others to prepare the present work. There are probably but few people of observation and practical experience who doubt the value of proper geological training for the engineer, since he must be prepared to meet and even to solve many problems which involve geological principles. For such knowledge it is necessary that the engineer should have adequate training in at least those fundamental principles of geology which relate to engineering problems. The authors have attempted to emphasize throughout the book the practical application of the topics treated to engineering work, because hitherto in many engineering courses of study the subject of geology has not been given the attention which they think it should receive from both professors and students. Although this book is intended primarily for civil engineers, it is hoped that it may be of use to others interested in applied geology. The book is excellently illustrated.

THE CHEMISTRY OF RUBBER. By B. D. Porritt. New York: D. Van Nostrand Company, 1913. 16mo.; 93 pp. Price, 75 cents.

The monograph is intended for those interested in rubber from a chemical point of view, and the description of technical practice has therefore been limited to the details which are necessary for a clear insight into the chemical questions involved. The literature of rubber is not as extensive as might be thought, and the present work fills a niche of its own.

X-RAYS. An Introduction to the Study of Röntgen Rays. By G. W. C. Kaye, B.A., D.Sc. New York: Longmans, Green & Co., 1914. 8vo.; 252 pp. Price, $1.25.

The present volume aims merely at giving an account of such of the present-day methods and apparatus as appear valuable or novel, and which in many cases can only be found scattered throughout many journals. It treats critically, and here and there more comprehensively, some of the features which have laid claim to the interests of the writer from time to time; it is concerned to some extent with the developments of theory as well as of experiment, and it attempts to convey a notion, however disconnected and ill-proportioned, of the historical trend of events from Prof. Röntgen's world-famous discovery in the year 1895 down to the end of the year 1913. The book is well illustrated by clear diagrams.

AT HOME IN THE WATER. Swimming, Diving, Life-saving, Water Sports, Natatoriums. By George H. Corsan. New York: International Committee of Young Men's Christian Associations, 1914. 16mo.; 197 pp. Price, $1.

The subject of swimming is constantly gaining in importance, and it is safe to say that at no time have there been as many competent swimmers as at the present. The volume before us is exceedingly valuable, dealing with swimming in all its phases; diving, life-saving and water sports. There is also a short chapter on the construction of swimming pools. In 1913, over 7,000 persons lost their lives through accidental drowning. It is a strange thing that many who are daily exposed to dangers from drowning do not know how to swim. This is true of lumbermen, of men in the navy, and of many who are members of crews on ships. Everyone should know how to swim for at least three reasons: First, it is a splendid form of exercise; second, it imparts self-reliance and courage; third, it might prove a means of saving lives. The Young Men's Christian Association has taken up this question in a very large way, their slogan being "Every Man and Boy in America a Swimmer." The author has introduced two new features in teaching swimming. In the first place, he heats the water in the pool to 80 degrees, so that the pupils will not suffer from cold. He also uses cotton water wings, which are used under the hips, so that the pupil can give all his attention to the arm movements. The volume will prove very valuable in public schools and summer camps and watering places. It will be found greatly helpful to individuals as a first effort in learning to swim.

PRATIQUE DE LA CONSTRUCTION. BETON ET MORTIER DE CIMENT. Armés ou non Armés. Avec Etablissement Rationnel des prix de Revient. By Frederick W. Taylor, M.E., Sc.D., and Sanford E. Thomson, S.B. Translated and adapted by M. Danas. Paris: H. Dunod et E. Pinat, 1914. 720 pp. Price, $5.50.

This is a translation of a work by two members of the American Society of Civil Engineers and goes into the whole subject in the greatest possible detail. It is filled with valuable tables and illustrations. The American practice has been very successful where concrete is concerned, and we are not surprised that French engineers have recognized its superiority.

AIDE-MEMOIRE DE L'INGENIEUR-CONSTRUCTEUR DE BETON ARMÉ. By Jean Braive. Paris: H. Dunod et E. Pinat, 1914. 387 pp. Price, $3.

This volume will prove of particular value in connection with the preceding work. It is accompanied by a large number of illustrations of executed work, diagrams, sections, plans, etc. It is also accompanied by an excellent glossary in five languages.

LA VIE DES VÉRITÉS. Par Dr. Gustave Le Bon. Paris: Ernest Flammarion, Editeur, 1914.

Admirers of Dr. Le Bon's works will be pleased to note the appearance of his latest volume, which, like the former ones of the series, is of a philosophical nature, but is written in a clear and easily-read style. The present volume is devoted to the subject of the various "truths," real or supposed, which prevailed during the course of ages, commencing with religious and moral ideas and philosophies, and coming down to the times of modern science. The latter portion of the work treats of the relation of science to other branches of knowledge, and the advantage which it possesses of being able to formulate laws which have a universal bearing. Owing to the wide scope of the work, we will not attempt to review all the subjects of which it treats, but its study will be of value to all who are interested in such questions. The author shows the results which are to be expected of science in the explanation of the universe, and also its limits and the "truths" which are still inaccessible to us, the work taking in all the recent ideas in this field. On the whole, the book claims the same interest as its predecessors.

SCIENCE ET RELIGION. Par Emile Boutroux. Paris: Ernest Flammarion, Editeur, 1913.

The time-honored conflict between science and religion is here presented in a new light by M. Boutroux, taking into account all the recent scientific theories such as prevail at the present time. He considers that religion and science each has its legitimate field which is distinct and separate, and that they do not deal with the same order of ideas, the conclusion being that in spite of their relations which can be said to exist in a certain degree, these two branches remain distinct, and even though there should be a conflict between them the result will only have the effect of strengthening each, seeing that both are endowed with a high degree of vitality. The book is ably written, and is a valuable contribution to this subject.

MODERN METHODS OF WATERPROOFING. Concrete and Other Structures. By Myron H. Lewis, C.E. New York: The Norman W. Henley Publishing Company, 1914. Price, 50 cents.

This reprint forms Chapter XXX of the author's new book, entitled, "Popular Handbook for Cement and Concrete Users." It is a condensed statement of the principles, rules and precautions to be observed in waterproofing and damp-proofing structures and structural materials.

CONQUEST OF THE TROPICS. By Frederick Upham Adams. Garden City, N. Y.: Doubleday, Page & Co., 1914. 12mo.; 368 pp. Price, $2 net.

The present handsome volume is the story of the creative enterprise conducted by the United Fruit Company, which has been so potent in the universal distribution of the banana and other tropical fruits. This book is the first in a series planned to describe certain big businesses, whose history and operation concern and should interest the public. The book is handsomely gotten up and reflects great credit on the author and publishers as well.

THE AMERICAN FERTILIZER HAND BOOK. Philadelphia: Ware Brothers Company, 1914. Quarto. Price, $1.

This is a standard reference book and directory of the commercial fertilizer industry and allied trades. It is in truth the buyers' guide of the trade, stating where to obtain plant-equipment, raw materials and the expert service required in the fertilizer industry. It contains special articles and statistics of interest to the fertilizer trade. It also contains a directory of the fertilizer manufacturers of the United States, together with a classified directory of the allied fertilizer trades; a directory of the cottonseed oil mills and a directory of packers and renderers. It is arranged in a very common sense manner, and the information given in each instance is very specific.

GUNSHOT INJURIES. How They Are Inflicted. Their Complication and Treatment. By Colonel Louis A. Lagarde, United States Army Medical Corps (Retired). New York: William Wood & Co., 1914. 8vo.; 398 pp. Price, $4 net.

The necessity for a book on gunshot injuries for use of the military service and the American surgical profession, was not apparent until very recently. The older volumes, such as those of Otis, supplied all the wants of the profession in this particular branch of surgery. But now the subject of gunshot injuries as a whole has been so modified by radical changes in the armament of the nations, and the results in wounds by firearms have been so modified by modern methods of treatment, that the works of Otis and his contemporaries have been entirely superseded as far as practical surgery is concerned. The demand of the military and civil surgeon now requires a presentation of the important subject of gunshot injuries as inflicted by a new armament and treated after the methods of modern surgical practice. The wounds produced by the firearms fifty years ago and the results of the treatment then in vogue form no guide for the study of the subject to-day. The author calls attention to the fact that there is very little difference between gunshot injuries in war and the gunshot wounds the civil practitioner is called upon to treat in civil practice. The subject is a peculiarly interesting one to all physicians and surgeons, and this book, which is a thorough scientific treatise, is worthy of every attention.

THE BACTERIOLOGICAL EXAMINATION OF FOOD AND WATER. By William G. Savage, B.Sc., M.D. (Lond.), D.P.H., Cambridge, England: University Press, 1914. 8vo.; 173 pp. Price, $2.

In view of the increasing importance of the study of public hygiene and the recognition by doctors, teachers, administrators and members of public health and hygiene committees, it is interesting to know that the Syndics of the Cambridge University Press have decided to publish a series of volumes dealing with the various subjects connected with public health. When it is considered that the regular text-books and manuals upon bacteriology are, for the most part, written by bacteriologists whose investigations and routine work are in the field of pathological bacteriology, it will be seen that there is a field for a work of another type. In marked contrast is the inadequate treatment given to the bacteriological examination of water, air, foods and the like. This branch of bacteriology is of immense practical importance, and justifies a more extended treatment. The aim of this volume is to remedy this defect and to make available a practical manual dealing not only with the examination of these substances, but also with the deductions to be drawn from the bacteriological data obtained from their examination. Much of the available information is only at present to be found in original papers not always readily accessible.

THE MENTAL HEALTH OF THE SCHOOL CHILD. The Psycho-Educational Clinic in Relation to Child Welfare. Contributions to a New Science of Orthophrenics and Orthosomatics. By J. E. Wallace Wallin, Ph.D. New Haven: Yale University Press, 1914. 12mo.; 463 pp. Price, $2.

Physical defects in children are not restricted to any clime, race, environment, or social condition. The children in sunny Southern California, no less than the children of the cold or humid North, East or West; the children of the country, no less than the children of the city; the children of the rich, no less than the children of the poor—labor under various forms of physical handicaps which are usually subject to amelioration or cure. Dr. Wallin has made a careful and prolonged investigation of the child mind. His conclusions are based on the statistical study. Realizing such facts as the above, he has set about to define the most effective means of correcting such deficiencies. The book contains tables which will be of the greatest service to all interested in the improvement of the conditions of children.

OUR MANY-SIDED NAVY. By R. W. Neeser. New Haven: Yale University Press. London: Humphrey Milford. Oxford University Press. 8vo.; 220 pp. 41 halftone engravings. Price, $2.50.

The United States Navy needs only to be known to be appreciated; and the only way to obtain a thorough knowledge of the navy is to go to sea in one of its ships, mingle with its officers and men, watch its maneuvers, target practice, boat drills, etc., and thus get into intimate touch with its daily life and service. This the author of the present volume has done, and probably there is no layman who has a more thorough knowledge of the navy, as to its organization, efficiency and daily life, than he. The handsome volume before us includes descriptions in the several chapters of "The Fleet at Sea," "The Naval Station at Guantanamo Bay," "The Organization of the Ship," "The Blue-Jacket's Daily Life," "The Battleship as an Educational Institution," "The Engineering Competition," "Athletes in the Navy," "The Sailor as a Soldier," "The Work of the Torpedo Flotilla," and "Target Practice." There are four appendices in which are described "The Navy's Services in Time of Peace," "Organization and Distribution," "The Organization of the Ship," and "The Weekly Routine on Shipboard." To a faculty of critical observation Mr. Neeser adds an attractive literary style, and the book teems with the atmosphere of the sea. Every chapter is thoroughly readable.

PHOTOGRAPHY IN COLORS. A Text Book for Amateurs and Students of Physics. By George Lindsay Johnson. New York: E. P. Dutton & Co. 16mo.; 243 pp. Price, $1.25 net.

This is the second edition of a valuable work on photography in colors and contains a chapter on kinematography in the colors of nature. The work has been so completely revised that it may be considered as a new book. The original sections have been recast and considerably amplified, while additional chapters on auto-color printing and on the nature of light, color and shadows, still further bring the book up to date. It is illustrated with thirteen full-page plates (five of which are in color), and numerous illustrations in the text.

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